The Development of the Chondrocranium of Ovis, together with some Aspects of the Development of the Osteocranium

Thesis for the Degree of Doctor of Philosophy

by

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Contents

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Introduction

It is a surprise to find on surveying the literature on the development of the mammalian chondrocranium that though several authors studied the chondrocranium of various mammals, no attempt has been made to trace systematically the development of the chondrocranium of Ovis, specimens of which are so easily available.

The pioneer workers in this field are Gaupp (1900), Noordenbos (1905), Broom (1895), Decker (1883), Edgeworth (1916), Fischer (1901), Fawcett (1905), Levi (1900), Voit (1909), Spurgat (1896), Wincza (1896), Mead (1909), Olmstead (1911) and Terry (1917).

De Beer's vast investigation in the field of the chondrocranium and his excellent arguments unfold many interesting features of the cartilages and their doubtful origin. Fawcett (1917) in his series of papers on the chondrocranium evolved an entirely new method of describing the primordial skull dividing it into (1) the central stem, (2) its appendages, (3) the lateral structures, (4) the commissures interconnecting these, and (5) the structures forming the roof. His method of description has been followed here as it gives a better impression of the developing cartilages with their relationship to the surrounding structures.

Broom (1895C) published a series of papers tracing the paraseptal cartilage in different animals which enabled him to divide the mammals into Archaeorhinata and Caenorhinata depending upon the presence of an outer bar of cartilage in the Jacobson's organ. Allis discusses the homologies of the trabeculae and the polar cartilages in some of his articles.

Decker (1883) in his description of the chondrocranium of mammals deals with only one stage of the primordial cranium of Ovis. Strum (1937) studied the nasal capsule of a fully developed specimen of Bos chondrocranium. Wincza (1896) studied the morphology of the mammalian skull and he too describes the cartilages of the primordial skull of Ovis at a particular stage in development.

Hence in this investigation an attempt has been made for the first time to trace systematically from the very beginning, the various constituents of the chondrocranium of Ovis which have revealed several interesting features. Specimens of Ovis belonging to the Orientalis Gmelin species were collected from the corporation abattoirs, Hyderabad (Deccan) for this work. Some gaps in the developing stages were filled in by the specimens collected locally from the abattoir in Edinburgh. It may be noted in passing that the present investigation reveals no difference whatsoever between the specimens of chondrocranium of Ovis collected in Edinburgh and those of the Indian Breed.

Method and Material

The sheep embryos required for this research work were collected in India from one of the Hyderabad (Deccan) Corporation abattoirs. Nearly 300 embryos were collected under various stages of development belonging to the Ovis orientalis Gmelin species. Since these specimens were collected at random from the abattoir the exact ages of the various embryos were difficult to establish and so crown rump length was measured both with calipers and nylon thread. These measurements were taken after fixation and preservation in 70% alcohol and so varied considerably due to a certain amount of shrinkage during fixation and also to the varied position of the fixed head in relation to the body. Hence it may be mentioned in passing that the crown rump length given in the chart separately indicates only the approximate measurements which are sufficient for the nature of the investigation undertaken for the study of the development of the chondrocranium.

Fixation:

Fresh specimens of sheep embryos were collected from the gravid uteri and were washed in several changes of warm normal saline solution to allow the blood to drain off completely. In the case of smaller specimens the entire embryo was treated in this manner, and the bigger specimens were decapitated at the root of the neck. The heads were washed in several changes of warm normal saline solution to drain off the blood from the cranial blood vessels. These specimens were divided into three batches and each batch was treated with different fixative. Three fixatives were used, namely, formalin, Van Wijhe and Susa.

I. Formalin 6%.

II. Van Wijhe's fixative.

0.5% mercuric chloride in dist. water	90c.c.
40% formalin (added just before use)	10c.c.

III. Susa.

Distilled water	200 c.c.
Mercuric chloride	11.25 gms.
40% formalin	200 c.c.
Acetic acid glacial	10 c.c.
Trichloro acetic acid	5 gms.
Sodium chloride	1.25 gms.

The duration of fixation depended upon the size of the material. Smaller specimens were fixed for 48 hours and larger specimens for a period extending up to 7 days.

After fixation the specimens were washed in 30%, 50% and 70% alcohol. Several changes of the last grade of alcohol were used to make sure, especially in the Van Wijhe and Susa fixed specimens, that the mercuric chloride was removed. From the last wash of 70% alcohol it was preserved in a fresh solution of 70% alcohol for future use.

Some of the specimens were used for mass staining of the chondrocranium by the Van Wijhe method with Victoria blue and Methylene blue stains. Some were subjected to serial sectioning for histological survey.

Mass Staining of the Chondrocranium by the Van Wijhe Method:

The specimens fixed in Van Wijhe fixative were divided into two batches and were treated in two different ways.

Batch I.

These specimens were removed from the last wash of 70% alcohol to iodine solution prepared in the following manner. Add 2 milliliters of Lugol's iodine to 100 milliliters of 70% alcohol.

Lugol's iodine -	Water	-	100 parts.
	Iodine	-	4 parts.
	Iodide of potassium	-	6 parts.

The duration of the specimens in the above iodine solution depended upon the size of the specimen. Then they were washed again in several changes of 70% alcohol till the last trace of iodine colour was removed from the specimen. These iodine treated specimens were transferred into a loosely woven gauze bag suspended in a tall, narrow, cylindrical specimen tube fitted with cork, containing the stain, Victoria blue or Methylene blue prepared in the following manner.

I.	Victoria blue	-	0.02 gms.
	Citric acid	-	21 gms.
	70% alcohol	-	1000 c.c.
II.	Methylene blue	-	0.01 gms.
	Citric acid	-	21 gms.
	70% alcohol	-	1000 c.c.

First the citric acid was dissolved in the 70% alcohol and then the stain was added to it in each of the above formulae.

The duration of the specimens in the staining fluid varied from 48 hours to more than 7 days depending upon the size of the specimen. The method of suspending the specimen in a gauze bag was adopted to ensure that no part of the specimen was touching the specimen tube and that all the parts of the material would come in contact freely with the staining solution. This method also facilitated easy handling of the delicate embryos.

Differentiation:

Next the differentiation was carried out by treating the stained specimens with buffer solution prepared in the following manner.

Buffer solution -	Citric acid -	21 gms.
	70% alcohol -	1000 c.c.

The stained specimens were suspended once again in fresh gauze bags in specimen jars containing the buffer solution several times the volume of the specimen. Streams of stain started coming out of the bag as the specimen was being differentiated. Several changes of the buffer solution were needed to completely differentiate the specimen and it took nearly two to three weeks depending upon the size. Then it was washed in 70% alcohol several times to remove the citric acid used in the buffer solution.

Dehydration:

The differentiated specimens were dehydrated by passing through higher grades of alcohol, 90%, 95%, and finally in two changes of absolute alcohol. The period of dehydration in each grade of alcohol depended upon the size of the specimen.

Clearing:

The dehydrated specimens were placed first into jars containing equal parts of absolute alcohol and benzene. Then they were transferred to pure benzene. When the specimens were thoroughly cleared, they were preserved in the oil of wintergreen or methyl salicylate.

Kodak's wetting agent, 1 to 2 drops for 8 ozs. of fluid, from the dehydrating alcohols to the clearing agent was used which increased the transparency of the specimens to a considerable extent.

Batch II.

The specimens belonging to this batch were not treated with Lugol's solution but were carried through the various stages as those of the first batch and were finally cleared and preserved in methyl salicylate.

Precautions observed:

1) Sufficient time was allowed in the fixative depending upon the size of the specimen. Smaller specimens were fixed for not less than 48 hours and the bigger ones for 7 days and more.

2) Similar duration was given in the dehydrating fluids as well as the staining solution.

3) Differentiation was carried out thoroughly so that with the exception of the cartilage all the surrounding tissues were free from stain. Incomplete differentiation rendered dissection of the material at a subsequent stage extremely difficult as the demarkation of the cartilage was

not clear from the surrounding tissue.

4) Dehydration after differentiation was carried out in higher grades of alcohol giving sufficient interval in each grade with a number of changes depending upon the size of the specimen. Treatment in absolute alcohol was similar.

5) Clearing was carried out only when the material was thoroughly dehydrated in the absolute alcohol.

6) In each of the above steps sufficient fluid several times the volume of the specimen was used.

Comments:

1) The specimens treated with Lugol's iodine were either very lightly stained or overstained. Even long differentiation in the buffer solution did not help to free the tissues surrounding the cartilage from the stain and so no cartilage could be identified either in the overstained specimens or in the lightly stained ones.

2) The specimens of the second batch which were not treated with Lugol's iodine reacted fairly well. The cartilages took up a deeper stain and the differentiation was quite successful, but the mercuric chloride crystals of the fixative were not dissolved even by a number of washes in 70% alcohol and so interfered with the transparency of the specimen. These crystals were visible as small specks giving a mottled appearance to the tissues surrounding the cartilage. Attempts to dissolve the crystals in the stained specimen did not help much.

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<u>Mass Staining of the Chondrocranium of the Specimens fixed in 6% Formalin:</u>

1) The specimens, after fixation and passage through 30% and 50% alcohol, were preserved in 70% alcohol.

2) These preserved specimens were treated with acid alcohol containing 1% HCL in 70% alcohol for two to three days.

3) Then they were stained in 0.25% solution of methylene blue in 1% acid alcohol (70%) or in the Victoria blue stain prepared according to the formula given above. The duration of the specimen in the stain depended upon the size of the specimen extending from 48 hours to 7 days.

4) Differentiation of the stained specimens was done in several changes of 1% acid alcohol.

5) Dehydration after differentiation was done in several changes of higher grades of alcohol giving sufficient time in each grade depending upon the size of the specimen. Complete dehydration was effected finally in two changes of absolute alcohol.

6) Cleared first in equal parts of absolute alcohol and benzene and then in two changes of pure benzene.

7) Cleared specimens were stored in the oil of winter-green or methyl salicylate.

The duration in each of the above fluids depended upon the size of the specimen. Kodak's wetting agent, 1 to 2 drops for 8 ozs. of fluid was added to the dehydrating fluids and the clearing agent which helped in rendering the specimens more transparent.

Precautions:

Same as stated above for the Van Wijhe method.

Comments:

The formalin fixed specimens reacted quite favourably with good results. The cartilaginous parts took up a deep and well defined stain. The differentiation was quite successful and the specimens cleared well with the greatest degree of transparency.

Preparation of Specimens for Serial Section Cutting and Microscopic Study:

Specimens fixed in Van Wijhe's fixative, Susa and formalin 6% and preserved in 70% alcohol were utilised. The frontal region of the head was pricked by a pin to allow the fluids at various stages of preparation to enter the ventricles by means of the vacuum pump in a vacuum embedder. Larger specimens were decalcified before they were taken through the various steps for embedding and section cutting.

Decalcifying solution -

5% aqueous solution of formalin	- 100 c.c.
Nitric acid (1.4 sp.g.)	- 7.5 to 15 c.c.

The larger specimens were kept in a large quantity of the above decalcifying solution, changing the fluid once or twice a day till the bones became soft and could be easily punctured with a needle. This indicated the complete decalcification. The smaller specimens were not decalcified as the bones were in a very early stage of development and could be easily sectioned. The decalcified specimens were treated with a 5% aqueous solution of sodium sulphate for twelve to forty-eight hours to wash off the acid and then in running water for an equal period.

Some specimens were cleared in benzene and others in chloroform. The following different timings were adopted.

Specimens cleared in Benzene:

Dehydration:

The specimens were dehydrated in the following grades of alcohol.

1) 90% alcohol I - 6 hrs.
2) 90% alcohol II - 3 hrs.
3) 100% alcohol I - 3 hrs.
4) 100% alcohol II - 3 hrs.

Clearing:

First the specimens were cleared in a mixture of equal parts of absolute alcohol and benzene and then in pure benzene.

1) Absolute alcohol and benzene equal parts - 1 hr.
2) Pure benzene - 4 hrs.

When the specimens were cleared thoroughly they were put in soft paraffin and in a vacuum embedder for six hours under a pressure of 500 to 600 inches to remove all the air bubbles from the various cavities of the head region and to allow the wax to permeate through the tissue. Every couple of hours the vacuum was broken and the specimen was agitated to release the possible air bubbles adhering to the sides of the ventricle. This method helped, to a great extent, to extricate all the air bubbles and to avoid them during embedding in hard paraffin.

Embedding:

From the soft paraffin the specimens were transferred to hard wax melting at 56°C. in a hot air oven for six hours and then were blocked.

Specimens cleared in Chloroform:

Dehydration:

1)	90% alcohol	- 12 hrs.
2)	100% alcohol with two changes	- 24 hrs.

Clearing:

1)	In a mixture of equal parts of absolute alcohol and chloroform	- 5 hrs.
2)	Pure chloroform with two changes	- 15 hrs.
3)	Soft wax and chloroform	- 2 hrs.
4)	Soft wax in vacuum embedder	- 4 hrs.
5)	Hard wax with two changes	- 3 hrs.

in each and then they were blocked.

Both the methods yielded good results. The only precaution observed in the larger specimens of the head was that the ventricles were punctured to let in the fluids at various stages and to let off the air bubbles.

Section Cutting:

Both the Cambridge Rocker and Spencer's Rotary Microtome were used for section cutting. The sections were cut at 10 microns and 15 microns and were mounted on clean slides.

Staining:

The slides were first stained with Meyers haemotoxylin and then were counterstained with an 0.5% aqueous solution of yellow eosin. This was used as a routine and the results were quite good. The sections of specimen which were fixed in fixatives containing mercuric chloride were treated with Lugol's iodine solution to dissolve the mercuric chloride crystals deposited in the tissue during fixation.

Dissection:

The heads of the whole stained specimens were dissected in the wintergreen oil under the dissecting microscope as well as the stereoscopic microscope using 10 x eye pieces and 1.25 objectives. The dissected specimens showing the cartilaginous portions were photographed.

Reconstruction of the Anterior Region of the Cartilaginous Nasal Capsule from Serial Sections by the Wax Plate Method:

Alternate sections of the serials cut at 15 microns were projected on a drawing board with the help of a prism attached to a microscope placed vertically at a distance of 1 metre, using 0 ocular and 1" objective. The figures were magnified 33.3 times the original. The outlines of the cartilages of the required part only were drawn on thin paper. When all the alternate sections belonging to the part required were drawn, wax plates of 1 m.m. thickness were prepared, with the diagrams attached to it on one side. A number of individual plates according to the number of diagrams were prepared. The outlines of the cartilages only were cut out of the wax plates, and assembled together according to their serial number, one over the other. A wax model, 33.3 times the original cartilage was formed which furnished details of the various cartilages with their intricate relationship and attachments. Plates LXIII, LXIV, show the above reconstructed model.

Staining of the Bones of the Osseous Cranium

The bones of the osseous cranium of the different aged foetuses were prepared and stained by the usual methods which do not require any detailed description. The procedure adopted was to divide the heads into three batches as follows -

I. Staining without maceration.

II. Staining after maceration.

III. Staining after decalcification and maceration.

The stain used on all the specimens was Alizarin Red S.

Alizarin Red S	-	0.1 gms.
70% alcohol	-	99.9 c.c.
1% Pot. Hydroxide solution	-	A few drops till the colour becomes deep red or violet.

Certain observations proved to be helpful, resulting in better preparations and giving greater clarification and delination. It might be emphasised that the period of time the tissues required varied with the density of the developing bone which can be gauged by the depth of staining of the superficial bones. It was also found that differentiation was better effected by careful observations rather than timing. Care was necessary to prevent all the stain disappearing. It was very important throughout to be most meticulous with each step and always to use fluids greatly in excess of the specimens. The degree of transparency of the specimens subject to the method used was in the reverse order of the arrangement of the batches, namely, III, II, I.

Embryos of Ovis Orientalis Gmelin fixed in Van Wijhe's Fixative. Measurements taken after fixing and preserving in 70% Alcohol

Crown rump length - C.R.L.
Head height - H.H. Head breadth - H.B.

Ser. Nos.	Log. Nos.	Measurements in Millimetres		Remarks
		Calipers	Nylon Thread	
1	A18	10mm.C.R.L.	18mm.C.R.L.	Stained in Methylene blue.
2	A17	11mm.C.R.L.	18mm.C.R.L.	" " "
3	A15	11mm.C.R.L.	18mm.C.R.L.	" " "
4	A14	13mm.C.R.L.	23mm.C.R.L.	" " "
5	A24	14mm.C.R.L.	24mm.C.R.L.	Stained in Victoria blue.
6	A13	15mm.C.R.L.	27mm.C.R.L.	Stained in Methylene blue.
7	A19	16mm.C.R.L.	24mm.C.R.L.	" " "
8	A12	18mm.C.R.L.	31mm.C.R.L.	" " "
9	A 8	20mm.C.R.L.	35mm.C.R.L.	" " "
10	A 5	21mm.C.R.L.	35mm.C.R.L.	" " "
11	A 3	23mm.C.R.L.	34mm.C.R.L.	" " "
12	A 1	28mm.C.R.L.	40mm.C.R.L.	" " "
13	A 2	29mm.C.R.L.	40mm.C.R.L.	" " "

Specimens fixed in Formalin. Measurements taken after fixing and preserving in 70% Alcohol.

1	C16	15mm.C.R.L.	25mm.C.R.L.	Stained in Victoria blue.
2	C17	16mm.C.R.L.	28mm.C.R.L.	" " "
3	C12	17mm.C.R.L.	29mm.C.R.L.	Stained in Methylene blue.
4	C 8	20mm.C.R.L.	30mm.C.R.L.	Stained in Victoria blue.
5	C14	23mm.C.R.L.	35mm.C.R.L.	" " "
6	C 1	26mm.C.R.L.	41mm.C.R.L.	Stained in Methylene blue.
7	C 2	28mm.C.R.L.	41mm.C.R.L.	" " "

Specimens fixed in Van Wijhe's fluid. Measurements taken after fixing and preserving in 70% Alcohol

Ser. Nos.	Log. Nos.	Measurements in Millimetres		Remarks
		Head Height	Head Breadth	
1	E 7	14mm. H.H.	11mm. H.B.	Stained in Victoria blue.
2	E 5	16mm. H.H.	10mm. H.B.	Stained in Methylene blue.
3	E 3	19mm. H.H.	12mm. H.B.	Stained in Victoria blue.
4	E10	20mm. H.H.	13mm. H.B.	" " "
5	E 1	23mm. H.H.	14mm. H.B.	" " "
6	E13	23mm. H.H.	14mm. H.B.	" " "
7	E11	25mm. H.H.	16mm. H.B.	" " "
8	E12	27mm. H.H.	17mm. H.B.	Stained in Methylene blue.

Specimens fixed in Formalin. Measurements taken after fixing and preserving in 70% Alcohol

1	G 8	12mm. H.H.	7mm. H.B.	Stained in Methylene blue.
2	G14	12mm. H.H.	7mm. H.B.	" " "
3	G 9	15mm. H.H.	8mm. H.B.	" " "
4	G11	15mm. H.H.	8mm. H.B.	" " "
5	G 7	16mm. H.H.	9mm. H.B.	Double staining by Toludin blue and Alizarin Red S.
6	G15	18mm. H.H.	11mm. H.B.	Stained in Methylene blue.
7	G10	18mm. H.H.	10mm. H.B.	" " "
8	G 6	19mm. H.H.	11mm. H.B.	" " "
9	G12	21mm. H.H.	12mm. H.B.	" " "
10	G20	24mm. H.H.	15mm. H.B.	" " "
11	G13	25mm. H.H.	15mm. H.B.	" " "
12	G16	26mm. H.H.	17mm. H.B.	" " "
13	G17	28mm. H.H.	18mm. H.B.	" " "

Specimens fixed in Van Wijhe Solution. Measurements taken before fixing and preserving. (Collected in Edinburgh).

Ser. Nos.	Log. Nos.	Measurements in Millimetres Calipers	Nylon Thread	Remarks
1	B12	21mm.C.R.L.	32mm.C.R.L.	Stained in Methylene blue.
2	B 2	23mm.C.R.L.	40mm.C.R.L.	" " "
3	B 3	23mm.C.R.L.	40mm.C.R.L.	" " "
4	B 4	23mm.C.R.L.	40mm.C.R.L.	" " "
5	B20	24mm.C.R.L.	40mm.C.R.L.	" " "
6	B27	24mm.C.R.L.	36mm.C.R.L.	" " "
7	B 8	28mm.C.R.L.	40mm.C.R.L.	" " "
8	B 6	37mm.C.R.L.	50mm.C.R.L.	" " "
9	B14	71mm.C.R.L.	88mm.C.R.L.	" " "

Specimen fixed in Van Wijhe Solution. Measurement taken before fixing and preserving (Collected in Edinburgh).

Ser. No.	Log. No.	Head Height	Head Breadth	Remarks
1	F 3	17mm. H.H.	10mm. H.H.	Stained in Methylene blue.

Specimens stained in Alizarin Red S.

Ser. Nos.	Log. Nos.	Fixative	Measurements in Millimetres	
			Calipers	Nylon Thread
1	A10	Van Wijhe	19 mm. C.R.L.	31 mm. C.R.L.
2	A 6	" "	21 mm. C.R.L.	34 mm. C.R.L.
3	A 9	" "	20 mm. C.R.L.	32 mm. C.R.L.
4	B 7	" "	31 mm. C.R.L.	42 mm. C.R.L.
5	B16	" "	28 mm. C.R.L.	44 mm. C.R.L.
6	B15	" "	27 mm. C.R.L.	38 mm. C.R.L.
7	B11	" "	30 mm. C.R.L.	45 mm. C.R.L.
8	B13	" "	41 mm. C.R.L.	62 mm. C.R.L.
9	C15	Formalin	24 mm. C.R.L.	36 mm. C.R.L.
10	E 8	Van Wijhe	13 mm. C.R.L.	14 mm. C.R.L.
11	E 4	" "	17 mm. C.R.L.	10 mm. C.R.L.
12	E 6	" "	16 mm. C.R.L.	10 mm. C.R.L.
13	E16	" "	24 mm. C.R.L.	15 mm. C.R.L.

Ser. Nos.	Log. Nos.	Fixative	Measurements in Millimetres	
			Head Height	Head Breadth
14	G 1	Formalin	28 mm. H.H.	18 mm. H.B.
15	G 2	"	22 mm. H.H.	15 mm. H.B.
16	G 3	"	22 mm. H.H.	14 mm. H.B.
17	G 4	"	16 mm. H.H.	10 mm. H.B.
18	G 5	"	13 mm. H.H.	8 mm. H.B.
19	G30	"	19 mm. H.H.	11 mm. H.B.
20	G29	"	31 mm. H.H.	20 mm. H.B.
21	G33	"	14 mm. H.H.	9 mm. H.B.
22	G34	"	17 mm. H.H.	11 mm. H.B.
23	G35	"	25 mm. H.H.	16 mm. H.B.
24	S 8	Susa	23 mm. H.H.	14 mm. H.B.
25	S 9	"	26 mm. H.H.	20 mm. H.B.
26	S10	"	20 mm. H.H.	11 mm. H.B.

Specimens for Section Cutting

A 1 - 13 m.m. C.R.L.

A22 - 15 m.m. C.R.L.

A23 - 17 m.m. C.R.L.

B 3 - 23 m.m. C.R.L.

C 4 - 25 m.m. C.R.L.

C 3 - 28 m.m. C.R.L.

C 9 - 20 m.m. C.R.L.

G18 - 14 m.m. H.H.

G19 - 21 m.m. H.H.

G28 - 22 m.m. H.H.

Stage I.

(Figs. I & II)

A 13 - 15 mm. C.R.L.

In Van Wijhe preparations of embryos of this stage there appears in the floor of the occipital region a pair of stained, roughly triangular patches, the occipitals. Each plate is broad, at its dorsal aspect and narrows down towards the medial side, facing the notochord. The staining is deeper, towards the broader end, and gradually becomes less deep as we trace it towards the notochord. This indicates two interesting points, namely, that the occipitals are as yet not fully chondrified and that the chondrification starts from the broad end dorsally and extends medially towards the notochord.

In this stage the anterior cervical vertebrae are seen as paired rudiments chondrified on either side of the notochord. The neural arches of the atlas are widely separated from the centrum and appear as triangular pieces, situated dorsally. Like the occipitals, the broad end of the neural arches are dorsal. The lateral ends of the centrum of the atlas are in contact with the lateral ends of the succeeding vertebra namely, the axis. Both the bodies joined together in the above manner take the shape of a signet ring with a cavity in the centre. The canalicular parts of the auditory capsule are in a pro-cartilaginous stage and appear as lightly stained isolated islands anterior to the occipital arches.

Stage II.

(Fig. III)

C 8 - 20 mm. C.R.L.

In this stage, the chondrification of the rudiments of the occipitals, is further advanced. From the triangular shape, described in the previous stage, the occipitals have become more curved laterally, as shown in the Fig. III. The chondrification has extended further medially, with the result a straight part and a laterally curved part are now recognised. In the angle between the straight part and the lateral occipital arch, on the anterior margin, is a deep notch for the roots of the hypoglossal nerve. The posterior margin of each notch, is of thicker and better developed cartilage, as indicated by the deeper stain it has taken by the Van Wijhe technique of cartilage staining.

The medio-ventral part of these notches are less chondrified. These are the posterior rudiments of the parachordals. It has been well established in all the vertebrates, that the parachordals develop from a paired origin, but Noordenbos mentions a single, unpaired origin, for the parachordals in Lepus, Bos and Sus. Fawcett (1918 A) has established in his description of the skull of Erinaceus, that the portion of cartilage medial to a line drawn in the antero-posterior direction of the hypoglossal foramen, belongs to the parachordal region and not to the occipital arches. Terry also confirms, in his description of the development of the chondrocranium in cat, that the parachordals arise in the form of paired stripes of cartilage on each side of the notochord. In accordance with these, it may be observed, that in the Ovis as well the parachordals develop from a paired origin.

The partly chondrified parachordals on either side of the notochord are joined together by a faintly stained young cartilage ventral to the notochord. The notochord extends forwards and appears to be in a tract of lightly blue stained tissue.

Each lateral occipital arch is cylindrical and joins medially the parachordals, as mentioned above. It is expanded laterally at its free extremity. The convex anterior margin is confluent with the lateral, whereas the posterior margin is nearly straight.

The cervical vertebrae show very little difference in their development, from the previous stage. The neural arches of the atlas are still widely separated from the centrum. The lateral ends of the centrum of the atlas and axis, which were joined in the form of signet rings in the previous stage, is now in the shape of a lozenge with a cavity of a similar shape in the centre, as shown in Fig. II. There is yet no sign of chondrification in the splanchno skeleton elements.

Stage III.

(Figs. IV & V)

A 12 - 18 mm. C.R.L.

There is not much advancement in the chondrification of the occipital region and the posterior rudiments of the parachordals as compared with the previous stage. The rudiments of the posterior parachordals are connected across the median plane, ventral to the notochord, by a faintly stained young cartilage. Microscopic examination of the serial sections of this stage, shows in the parachordal region two kinds of cells; cells with the lowest degree of histological differentiation of mesenchyme into cartilage which extend across the notochord ventrally and cells with well advanced chondrification, extending laterally, into the lateral occipital arches. It is evident from this that the posterior parachordals are not yet fully chondrified.

The occipital arches have extended further dorsally and are beginning to curve inwards, towards one another. The notochord extends forward and appears to lie between two strips of faintly stained tissue, which is more clear than in the previous stage. Anterior to the tip of the notochord the tissue is stained a little broader to become once again a very narrow strip extending forwards.

The interesting point in this stage is the first appearance of the trabecula, medially, in the form of a thin strip of faintly stained tissue, anterior to the notochord.

The neural arches of the atlas are still widely separated from the corresponding centrum and are open dorsally. In the lozenge shaped centrums of the atlas and axis, the lateral extremities and the central parts are deeply stained, with an intermediate zone of a lightly stained part. The deeply stained portions indicate an advanced chondrification in the tissue surrounding the notochord. The cavity in the centre of the lozenge shaped body still persists. Between the primordial centrum of the atlas and the posterior border of the posterior rudiments of the parachordals, the notochord lies in a free zone, without being surrounded by any chondrified tissue, as shown by the absence of the blue stain about it.

Stage IV.

(Figs. VI & VII)

C 10 - 18 mm. C.R.L.

The central stem of the neurocranium is that which stretches on the floor of the neurocranium, from the anterior margin of the foramen magnum to the tip of the nose in an antero-posterior direction. It is divided into various sections, for convenience of description, according to the morphological parts of which it is constituted. Describing them from behind forwards they are as follows:-

1) Pars chordalis (basal plate) - the portion which encloses the notochord.

2) Pars tuberalis - consisting of the hypophyseal

cartilage and its stomodeal duct.

3) Pars interorbito-nasalis or interorbito nasal septum - a part of which lies between the optic foramen, then as traced forward between the orbital cavities and finally within the nasal cavity as the nasal septum.

The parachordal region is also known as the basal plate. The term basal plate is used to indicate that portion of the floor of the neurocranium which extends in an antero-posterior direction, enclosing the cranial portion of the notochord. The boundaries of the basal plate may be described as follows:-

Anteriorly it is limited by the crista transversa, posteriorly by the ventral margin of the foramen magnum, while the lateral margins stretch up to the level of the basal foramina and cochlear capsule.

The central stem shows better development in this stage. The basal plate is clearer and its margins are well defined. It is broad in the occipital region, attaining its final shape as shown in Fig. VI and stretches as a narrow strip on either side of the notochord. The lateral occipital arches and part of the basal plate (posterior rudiments of the parachordals) are fully chondrified as indicated by the deeper staining. The rest of the basal plate is in the form of procartilage, as evidenced by the lighter staining. The procartilaginous basal plate does not extend its entire length, but stops a little distance from the rest of the central stem. The rest of the central stem consists of the hypophyseal cartilage (de Beer) and the nasal part of the central stem. The hypophyseal cartilage is interposed between the nasal septum and the basal plate.

Generally it is considered that the floor of the chondrocranium consists of two portions namely, parachordals or basal plate behind, and the trabeculae in front, continuing as the nasal septum. It has been established by a number of authors, Van Wijhe (1904, 1922), Veit (1911) and Sonies (1907) that the trabecula consists of an anterior trabecular portion (nasal septum) and a posterior polar element. In the lower vertebrates, the polar cartilages are situated behind the trabeculae, lateral to the internal carotid arteries, and are connected across by a medial plate of cartilage, known as the hypophyseal plate. The internal carotid arteries enter the cranial cavity on either side of the hypophyseal cartilage.

In placental mammals, the polar cartilages are represented by the alicochlear commissures, which stretch from the cochlear part of the auditory capsule to the processus alaris, thus forming the external boundary of the foramen through which the artery passes. The processus alaris of the mammal is known as the basipterygoid or basitrabecular process in lower vertebrates and it develops from the polar cartilages. Even so, in the mammals the alicochlear commissure bears the processus alaris. Hence, it follows that the plate of cartilage, situated medially and median to the arteries, is the hypophyseal cartilage (de Beer).

This cartilage has been called the polar plates by Noordenbos and the pars tuberalis of the central stem by Fawcett. On the evidence of new observations, Fawcett has divided the central stem into three parts. They are from behind forwards, pars chordalis (basal plate), pars trabecularis in the middle and the pars interorbito-nasalis in front. The hypophyseal cartilage belongs to the trabecularis of Fawcett's description.

In the specimen of Ovis under consideration, the hypophyseal cartilage has already joined the anterior trabecular part (nasal septum) or the interorbito-nasal septum (Fawcett). The line of junction is seen as a faintly stained transverse line, but the fusion with the basal plate has not yet taken place, as indicated by a gap of unstained portion in between.

The basal plate and the hypophyseal cartilage are flat, whereas the nasal part of the central stem (pars interorbito-nasalis of Fawcett), grades off into a vertical plate which extends up to two-thirds of the length of the nose. The entire length of the central stem is not in one plane. From the hypophyseal cartilage, the anterior portion (nasal septum) curves down, making an angle with the basal plate. The height of the nasal septum increases gradually from the junction of the hypophyseal cartilage up to a certain distance, and then diminishes anteriorly. There is considerable variation in the thickness of the central stem as well. In the region of the basal plate, it is broad posteriorly and becomes narrower anteriorly up to the termination of the notochord. In the hypophyseal region it is like a quadrilateral plate, with the broad end towards the parachordals, and the narrower end facing the nasal septum, and in the nasal region the breadth of the central stem decreases while the height gradually increases as stated above.

The notches for the roots of the hypoglossal nerve are still open without being converted into a foramen. The lateral occipital arches are curved more inwards towards one another.

Two new centres of chondrification draw our attention at this stage. The canalicular part of the auditory capsules is seen as a separate oval shaped structure situated in front of the lateral occipital arches. It is not connected with any part of the neurocranium. Being transparent the septa semicircularia are clearly visible.

In the cervical region the neural arches of the atlas have grown further and are connected medially across by a thin strip of procartilage, ventral to the notochord. Each lateral extremity of the arch presents two processes, the neural and the atlantal.

In the visceral skeleton the Meckel's cartilage makes its appearance for the first time. It is in the form of a thin procartilaginous rod, slanting downwards and forwards, being unconnected with any part of the neurocranium. The malleus is absent since the Meckel's cartilage has not yet extended posteriorly.

Stage V.

(Figs. VIII & IX)

C 14 - 23 mm. C.R.L.

There is not much change in the shape and size of the central stem. The basal plate is wide and concave behind, forming the anterior boundary of the future foramen magnum. The anterior limit of the basal plate is now clearly indicated by a deeply stained line running transversely, anterior to the notochord, the crista transversa. The basal plate is now complete with the major portion of it in the form of procartilage. The notochord is seen running along the medial line surrounded by deeply stained tissue. The lateral boundaries of the basal plate are visible as thin curved lines extending from the anterior margin of the posterior parachordals up to the crista transversa anteriorly. The occipitals are attached to the postero-lateral angles of the basal plate.

The lateral occipital arches are more curved towards one another than in the previous stage. Each lateral occipital arch passes backwards and outwards, the anterior margin of which forms the posterior boundary of the future foramen jugulare, whereas the posterior margin of these arches forms the lateral boundary of the foramen magnum.

Another advancement which is easily perceptible is the conversion of the deep notches for the roots of the hypoglossal nerve into foramen. In this stage there is only one foramen on each side of the notochord.

Hypophyseal cartilage is visible in the form of paired patches on either side of the hypophyseal foramen. The junctions between this cartilage and the parachordals and trabecula are indicated by faintly stained lines running transversely. Viewing the central stem laterally it is found that the hypophyseal regions contains a deep depression as shown in Fig. IX, the sella turcica, in which the pituitary gland is lodged. In front of this depression the central stem rises once again, forming an elevation, thus limiting the anterior boundary of the sella turcica. This elevation is known as the tuberculum sellae.

The hypophyseal cartilage in the rabbit starts in the form of a ring surrounding the hypophyseal foramen (de Beer). In Felis the cartilage is like a bar behind the hypophyseal stalk. In other forms namely, Homo, Echidna, this cartilage is a paired patch situated one on each side of the hypophyseal foramen - the right and the left. It is observed, that in Ovis as well the hypophyseal cartilage has a paired origin, the right and the left, on either side of the hypophyseal foramen.

The auditory capsules are still in the procartilaginous stage, as isolated structures situated anterior to the occipital arches. There is not much advancement in the development of the Meckel's cartilage. No other splanchno skeleton is visible.

Stage VI.

(Figs. X & XI)

A 5 - 21 mm. C.R.L.

Several interesting features draw our attention in this stage. The occipitals have taken a definite shape. Though the dorsal portion of the occipital arches is in the form of two curved plates, the ventral portion is a three sided mass. The posterior angle of this mass is directed backwards, where the articular facets for the atlas develop. The anterior angle forms the lamina alaris, separated from the canalicular part of the auditory capsule by means of a fissure, in this stage. The lamina alaris is continued downwards as the paracondylar process of the occipitals.

Morphologically these processes are considered as the transverse processes of the cervical vertebrae which are incorporated into the occipital region of the skull (Voit 1909, Gaupp 1900). These are found in almost all the mammals and in a better developed condition in Rodents. The medial angle of the mass is joined to the postero-lateral angles of the parachordals with the hypoglossal foramen in between.

New structures are attached to the dorsal border of the occipital arches, the supra occipitals which are in the procartilaginous stage. They are quadrilateral curved plates, situated posterior to the canalicular part of the auditory capsule from which it is separated by a wide fissure, the occipito-capsular fissure. The junction between the occipital and the supraoccipitals is still clearly visible. The lateral surface is convex and the medial surface facing the cranial cavity is correspondingly concave.

The central stem, with its various constituents fused together, is now continuous extending from the foramen magnum behind to the tip of the nasal septum anteriorly. But still, the place of junction between the trabecula and the hypophyseal cartilage, and between the latter and the basal plate is evident, from the light staining of the young cartilaginous tissue in these places. The basal plate is wide behind and becomes gradually narrower anteriorly with concave lateral borders. There is not much change in the shape of the hypophyseal cartilage. It shows on its dorsal surface a depression, the sella turcica or pituitary fossa in which the pituitary gland is lodged. This fossa is limited anteriorly by a slight elevation in the dorsal surface of the stem, the tuberculum sellae. Anterior to this tuberculum sellae, there is a slight depression of the central stem, followed by a sudden rise as it becomes a vertical plate and continues as the nasal septum. The second depression is known as the fossa hypochiasmatica and lodges the optic chiasma.

Opposite the junction of the hypophyseal cartilage with the trabecula, the rudiments of the metoptic roots of the orbital cartilages (ala orbitalis) appear on either side in the form of paired rod-like structures, directed outwards and forwards, separated from the central stem. The orbital cartilages are seen as shadows, lightly stained, with an ill-defined border, isolated from the metoptic roots. There is yet no sign of the preoptic root of the orbital cartilages.

The nasal or the ethmoidal region is of great interest. The nasal septum has extended further anteriorly than in the previous stage. It is not of uniform height, but after reaching the maximum height, about the middle of the length of the nose, it gradually slopes down. Three new cartilages are visible in the ethmoid region of this stage. In the fully formed chondrocranium, three parts of the nasal capsule are recognised, which develop from three independent centres of chondrification, the parietotectal, the paranasal and the orbito-nasalis (planum antorbitale). Of the three parts the first part to develop is the parietotectal cartilage which begins as a scroll on either side of the dorsal edge of the nasal septum. This scroll develops further enclosing the nasal capsule and forming the roof and the anterior part of the side wall in each side of the ethmoidal region. The anterior border of this cartilage forms the fenestra narina or the external nasal aperture.

Ventrally it does not cover the nasal capsule and leaves a gap, the fenestra basalis on each side of the nasal septum.

The second part to chondrify is the paired paranasal cartilages. They project sideways, forming a well marked globular protuberance. The union between the parietotectal and the paranasal cartilages is indicated externally by a shallow groove, known as the sulcus lateralis anterior. At the junction of the parietotectal with the paranasal, dorsally, a small foramen, the epiphanial foramen is left for the passage of the nasal branch of the trigeminal nerve. The posterior margin of the paranasal cartilage forms the anterior boundary of the fenestra cribrosa through which the olfactory nerves enter the nasal capsule. It is through this fenestra cribrosa the nasal capsule opens dorsally into the cranial cavity.

Lastly the orbitonasal cartilage chondrifies extending downwards and backwards from the paranasal cartilage. A shallow depression, the sulcus lateralis posterior, marks the union of these two cartilages. The posterior part of the orbitonasal cartilage curves inwards, forming the posterior wall of the nasal cavity, the cupula posterior.

In the specimen under consideration the parietotectal and the paranasal cartilages are already formed, whereas the orbitonasal cartilage (planum antorbitale) is in a very early stage of development. The staining of the nasal cartilages is not uniform. Though the parietotectal cartilages are formed earlier than the paranasal cartilages they have taken a deeper stain posteriorly and are without any stain in the anterior region. Thus the recognition of the fenestra narina is rendered difficult. The foramen epiphanial at the junction of the parietotectal and the paranasal cartilages dorsally, is clearly visible. On the lateral side of the nasal capsule, the sulcus lateralis anterior is visible in the form of a groove, whereas the sulcus lateralis posterior is not yet formed, as the orbito-nasal cartilage is in the early stages of development. The paranasal cartilages protrude laterally in the form of globular structures.

The canalicular part of the auditory capsule is now chondrified on all sides and is situated anteriorly to the occipital arches and dorso-lateral to the central stem. It is not yet anchored to any part of the neurocranium and so stands as an isolated structure. The shape of the canalicular part is roughly triangular with the base towards the floor of the neurocranium and with the angles rounded off. The semicircular canals are indicated by the deeper staining of the tissue surrounding the canals. The lateral wall of the canalicular capsules overhangs latero-ventrally in the form of a straight ridge known as the crista parotica. The capsule stands nearly vertical forming the side wall of the cranial cavity posteriorly. The long axis of this capsule is forwards and outwards in an a postero-anterior direction with slight inclination downwards.

There is greater development in the Meckel's cartilage. From an isolated thin rod, directed downwards and forwards, it has grown further in both, anterior and posterior directions. Anteriorly it extends as far as the level of the fenestra narina and is separated from the fellow of the opposite side by a narrow gap. The posterior extremity near the auditory capsule is still in the procartilaginous stage as evidenced by the light staining. The malleus, the incus and the stapes are perceptible as shadows lightly stained without definite line of demarkation.

In the splanchno skeleton another new cartilage makes its appearance, the stylohyal cartilage. This cartilage is like an isolated rod with slightly expanded extremities, directed downwards, forwards and inwards. Except the above mentioned cartilages in the splanchno skeleton there is no sign of any other cartilaginous elements in this stage.

Stage VII

(Figs. XII, XIII, XIV, XV, XVI)

C 1 - 26 mm. C.R.L.

Some more advancement is made in this stage. The basal plate is precisely the same in shape and size as in the previous stage. The occipital arches are more curved and the condylar processes are more prominently directed downwards. The supraoccipitals have taken a definite shape, but the junction between this cartilage and the occipitals is still clearly visible. The antero-lateral corner of the supraoccipital which was farther apart from the canalicular part of the auditory capsule is now in contact with it.

In the previous stage the supraoccipitals were separated from the canalicular part of the auditory capsule by an extensive occipito-capsular fissure on account of which the jugular foramen and the occipito-capsular fissure were continuous. The occipito-capsular fissure extends antero-posteriorly on the dorsal border of the entire length of the canalicular part. In this stage the fissure is divided into two parts by the approximation of the antero-lateral corner of the supraoccipitals, thus dividing the fissure into occipito-capsularis superior and occipito-capsularis inferior. The occipito-capsularis superior is also known as the parieto-capsularis or foramen jugulare spurium (Fig. XV). In this stage the occipito-capsularis superior is open anteriorly since the parietals are yet to be formed. The occipito-capsularis inferior is further divided into the foramen jugulare by the approximation of the lamina alaris with the canalicular part of the auditory capsule. At the place where the lamina alaris will come in contact with the auditory capsule, small projections jutting out from the lamina alaris and from the capsule are seen stained lightly. Thus there is an indication of the formation of the jugular foramen (Fig. XV).

The hypophyseal cartilage is now definitely joined to the basal plate posteriorly and the trabecula anteriorly. At the place where the basal plate joins the hypophyseal cartilage, the former is expanded as shown in Fig. XVI. At the junction of these two cartilages, a new structure is seen, extending outwards and forwards, the ala temporalis.

The basipterygoid or basitrabecular process in lower animals is known as the processus alaris in mammals. This processus alaris develops as an outward extension from the central stem at the posterior end of the trabecula, at the junction of the hypophyseal cartilage with the basal plate. The alicochlear commissure, which represents the polar cartilages, forms the external boundary of the carotid foramen and bears the processus alaris (de Beer, 1930). To this processus alaris is attached the ala temporalis. The ala temporalis is regarded as the homologue of the processus ascendens of the pterygo-quadrate or palato-quadrate cartilage. The palato-quadrate is connected with the chondrocranium by means of four processes, basal process, otic process, ascending process and the pterygoid process.

The ascending process is anterior to the otic process and grows up between the profundus branch of the trigeminal nerve and the maxillary and mandibular branches. In mammals the ala temporalis, rises between the maxillary and mandibular branches of the trigeminal nerve, Broom (1907, 1909a, 1914) has shown that the ala temporalis corresponds to the processus ascendens of the lower tetrapods and that it could be evolved from the processus ascendens. This processus ascendens becomes ossified as the epipterygoid in reptiles. The processus ascendens in its transition to ala temporalis moves backwards, enclosing the maxillary branch of the trigeminal nerve in a foramen, the foramen rotundum. Hence it has been argued out that the ala temporalis chondrifies separately and becomes connected with the processus alaris as opposed to the view of Gaupp (1902) that the processus alaris and the ala temporalis together form the basitrabecular process.

In the specimen under consideration the ala temporalis and the processus alaris are continuous and are joined to the central stem. The junction between the ala temporalis and the processus alaris is not visible but the union with the central stem is indicated by the intermediate zone lightly stained. The alicochlear commissure is seen as a lightly stained link between the processus alaris and the cochlear part of the auditory capsule. Thus the carotid foramen for the passage of one of the branches of the external carotid arteries is seen on either side of the central stem as a complete foramen.

Various theories have been put forward regarding the formation of the ala temporalis and its connection with the central stem by means of the processus alaris. Accordingly, two types of development are recognised. In one the ala temporalis develops in continuity with the central stem and in the other it develops as a separate cartilage and becomes connected to the central stem by the processus alaris.

Wincza's observation of the ala temporalis as a separate, independent chondrifying centre in the cat led him to trace the development of this cartilage in other animals. In the dog embryo, he found a separating zone between the ala temporalis (alisphenoid) and the processus alaris (basisphenoid). The terms alisphenoid and basisphenoid are used when these cartilages, ala temporalis and processus alaris become ossified. Likewise, a separating zone has been found between these two cartilages by Wincza in the polar bear, in man, in hedgehog. Wincza's observations in man were confirmed by Levis, Gaupp and Fawcett. In Lepus a separate zone has been observed by Noordenbos, Voit and Fuchs.

The second type is characterised by the development of the ala temporalis in continuity with the basi cranii. This has been observed in horse, sheep, pig and calf by Wincza. From these observations it is clear that in some mammals the ala temporalis begins as a distinct, independent cartilage and becomes attached to the central stem while in others it grows as a simple process, continuous with the central stem.

An observation in Ovis regarding the development of the ala temporalis is that it belongs to the first type of development described above. In the adult two laminae are attached to the ala temporalis, lamina ascendens and lamina pterygoid. In this stage the beginning of these laminae are seen only as processes (Fig. XVI).

The metoptic roots of the orbital cartilage, which were in the form of isolated rods directed outwards and forwards in the previous stage, are now joined to the central stem at the junction of the hypophyseal cartilage with the trabecula. These roots have also extended further in length like rods bent forward. The preoptic roots of the orbital cartilages are visible as projections from the central stem behind the lamina orbito-nasalis (Fig. XII). It has been observed by de Beer (1930) in Lepus that the preoptic roots extend from the orbital cartilages towards the central stem. In Ovis it is in the opposite direction, that is, from the central stem towards the orbital cartilages, which is a point of interest.

In the ethmoid region the lamina orbito-nasalis shows further development but it is still separated from the paranasalis with the result the sulcus lateralis posterior is absent. The parietotectal and the paranasal cartilage show no further development than in the previous stage. As the anterior region of the ethmoid is not stained the details of this region are not perceptible.

The canalicular part of the auditory capsule is still isolated from the central stem. It is more chondrified than in the previous stages as evidenced by the deeper staining it has taken. The crista parotica is clearer.

In the splanchno skeleton further advancement in the way of development of new cartilages is noticeable. The anterior extremity of the Meckel's cartilages are still apart, without being joined together. The posterior extremity of the Meckel's cartilage is seen as a slightly stained bent rod indicating the formation of the future malleus. Behind the malleus and anterior to the crista parotica, in between lies the incus, which appears in this stage as an isolated cartilage with two arms, crus longum and crus breve. The stapes has not yet appeared.

Near the posterior third of the crista parotica is seen a small rod of cartilage detached from the auditory capsule but lying close to the crista parotica, the laterohyal. The laterohyal is chondrified only at the dorsal extremity and the rest of it is seen as a transparent rod being attached to the dorsal extremity of the stylohyal cartilage. This combined cartilage formed of stylohyal and laterohyal is known as Reichert's cartilage. Noordenbos (1905) found the Reichert's cartilage chondrifying as a single piece, whereas, de Beer and Woodger (1930) found in Lepus, two centres of chondrification, arising separately and then uniting as a single rod to which the term Reichert's cartilage is applied.

In Ovis, I found that the Reichert's cartilage develops from two separate independent centres of chondrification, one for the laterohyal and another for the stylohyal (Fig. XV).

Stage VIII

(Figs. XVII, XVIII, XIX, XX)

A 7 - 20 mm. C.R.L.

The central stem is completely chondrified from the anterior end of the nasal septum (trabecula) to the posterior border of the parachordals or the ventral margin of the future foramen magnum. In the basal plate even the few parts which were procartilaginous in the previous stage are now fully chondrified, with the result the basal plate has taken a uniform deep blue colour throughout. The demarkation at the junction of the occipital arches and the postero-lateral part of the parachordals has disappeared and it conveys the idea that the basal plate and the occipital arches are all made up of one plate of cartilage. The notochord is seen along the medial line as in the previous stages but not it is completely surrounded by cartilage (Fig. XVII).

The hypoglossal foramina which started as a pair of notches at the beginning are now complete foramina and there is a tendency for each foramen to double by constriction in the middle (Fig. XX).

The central stem is now continuous without any transverse lines indicating the junction between the various constituents. The hypophyseal cartilage is now uniformly stained, thus showing the complete chondrification. The ala temporalis situated at the junction of the posterior end of the hypophyseal cartilage and the anterior extremity of the basal plate is still in the procartilaginous stage and the development is not so advanced as in the previous stage. In the normal course of development, the ala temporalis should either have been in the same state of development as in the previous stage or should have shown further advancement. In this stage though the development of the chondrocranium is a little more advanced in some respects than in the previous one, the ala temporalis for some reason or other is in an underdeveloped condition. This underdeveloped condition is peculiar to the specimen under consideration and must be regarded as a variation in this particular individual specimen. On account of the poor development of the ala temporalis the carotid foramina for the passage of the arteries are not formed, moreover, there is no indication of the formation of the alicochlear commissure.

The orbital cartilages are better developed than in the previous stage but they are still in the procartilaginous form, as indicated by the light staining they have taken (Figs. XVII, XX). These cartilages are connected to the central stem by two roots, the preoptic and the metoptic.

The metoptic roots of the orbital cartilages started as isolated rod-like structures, on either side of the central stem in the region of the junction of the trabecula with the hypophyseal cartilage. In this stage they are not only connected with the central stem but also with the orbital cartilages. They appear as bent rods, directed outwards and forwards. The preoptic roots are still procartilaginous. The union of the orbital cartilages with the central stem through these two roots encloses a foramen in between the roots, the foramen opticum. Through this foramen opticum passes the optic nerve. The shape of the foramen is nearly oval. It is bounded on the medial side by the basi cranii, on the lateral side by the orbital cartilage and by the preoptic and metoptic roots on the anterior and posterior sides respectively (Fig. XVII).

The orbital cartilages are sickle shaped structures projecting from the basi cranii outwards and upwards. They form the medial wall of the optic cavity in which the eye is lodged and the lateral wall of the anterior part of the cranial cavity. The borders of these cartilages are not yet well defined and they are free from attachment to any other part of the neurocranium, except the ones mentioned above. The postero-lateral extremities of these cartilages are extended in the form of thin strips as shown in Fig. XX.

In the ethmoid region no further development is noticeable than in the previous stage. The paranasal and the parietotectal cartilages still leave a gap on the ventral surface of the nasal capsule. The orbitonasal cartilages show no further development (Fig. XVIII).

In the auditory region, the canalicular part of the auditory capsule is fully chondrified and stands out as an isolated body unconnected with any part of the neurocranium. As mentioned above, though this stage is an advanced one over the previous in certain respects, some parts are under-developed and may be considered purely as variations of this particular specimen. The occipito-capsular fissure which was divided into occipito-capsularis superior and occipito-capsularis inferior by the approximation of the antero-lateral part of the supraoccipitals, is in this specimen undivided and is continuous. The formation of the jugular foramen is indicated by the approximation of the lamina alaris and a process from the postero-dorsal margin of the canalicular part. The paracondylar process is remarkably prominent (Fig. XVIII).

In the splanchno skeleton the laterohyal shows further development in the form of a procartilaginous rod, now connected to the dorsal extremity of the stylohyal. The dorsal extremity of the laterohyal extends as far as the crista parotica of the canalicular part of the auditory capsule but is still free from being attached to it. The stylohyal is in the form of a rod expanded slightly at the dorsal extremity where it is attached to the laterohyal. It is fully chondrified, as indicated by the deep stain it has taken, (Fig. XIX).

The Meckel's cartilage shows no further development except at the posterior extremity. The anterior ends are still separated from each other by a narrow gap. The posterior extremity now shows the formation of the malleus in the form of bent structures of procartilage as shown in Fig. XVIII. The incus also can be seen clearly with its two arms, crus longus and crus breve. There is yet no sign of the stapes (Fig. XVIII).

Stage IX.

(Figs. XXI, XXII, XXIII, XXIV, XXV,
XXVI, XXVII, XXVIII, XXIX, XXX).

A 1 - 28 mm. C.R.L.

The chondrocranium is in a better state of development than that of the previous stage. In the occipital region the hypoglossal foramina which were single on each side of the notochord and which showed a tendency to become double, have now become paired on each side. The foramina are placed one behind the other in an antero-posterior direction, the anterior of which is the smaller of the two. The number of these hypoglossal foramina on each side of the notochord not only varies in different species but also in the same individual. Voit noticed in Lepus paired hypoglossal foramina on each side of the notochord. Fischer described in an embryo of Semnopithecus pruinosus, two hypoglossal foramina on the left side and three on the right side, whereas in Semnopithecus maurus, a single foramen on each side. This shows that variation may occur not only in a single genus but also in the individual species (Fig. XXI).

In the sheep embryo a pair of hypoglossal foramina are seen on each side of the notochord, which is a constant feature in almost all the embryos in which there is an advanced development of the chondrocranium.

On their external surface, postero-ventrally, the occipital arches show two condyles by which they articulate with the first segment of the cervical vertebra. The condyles appear as rounded convex structures scarcely projecting out from the general surface of the skull. The paracondylar processes are remarkably prominent. The lamina alaris is still separated from the canalicular part of the auditory capsule and is in the same degree of development as that of the previous stage. The union between the lateral occipital arches and the supraoccipitals is still distinct (Fig. XXII).

The ala temporalis shows further development of the processes. The pterygoid process is directed downwards and forwards from the anterior border of the ala temporalis. The processus ascendens is in the form of a forked plate-like structure with a deep notch at the outer extremity (Fig. XXIII). Since it is not upstanding as in other mammals, the term lamina ascendens cannot be suitably applied here. The ala temporalis appears as a strap-like structure continuous with the basal plate, extending outward at the junction of the hypophyseal cartilage and the anterior extremity of the basal plate. The junction of the ala temporalis with the basal plate is indicated by a faint margin of thin cartilaginous tissue, which has taken a fainter stain than the surrounding area. This line of junction indicates that the ala temporalis is a separate structure from the basal plate and that it became attached to the antero-lateral extremity of the basal plate at a later stage and is not a continuous process extending from the basal plate. This view is contrary to Wincza's statement, who had observed the ala temporalis in sheep as a continuous structure extending from the basal plate. In earlier stages of Homo, Felis, and Canis, Wincza (1896) found the ascending part of the ala temporalis chondrifying as a separate piece of cartilage and later uniting with the processus alaris.

In the specimens of sheep examined so far the ala temporalis does not appear as an isolated structure separated from the basal plate. From the structure of the tissue at its junction with the basal plate it would appear to have started as a separate body and later become attached to the basal plate.

There is nothing particular to mention regarding the hypophyseal cartilage. As already stated it has reached a complete stage of chondrification.

In this stage the ala orbitalis is more advanced in chondrification than that of the previous stage. The borders are well defined and the sickle shape of the cartilage is clearer. It is attached to the preoptic and metoptic roots, which in turn are fused to the central stem. In between these roots is the optic foramen for the passage of the optic nerve. The sickle shaped ala orbitalis is attached at its postero-lateral corner to a new structure, the commissure orbito-parietalis which is in a procartilaginous state. The orbito-parietal commissure connects the orbital cartilage with the parietal of its side (Fig. XXI).

Another important point of interest is the development of the cartilage, the ala hypochiasmatica, attached to the metoptic root of the ala orbitalis. In this stage it is seen as a small process jutting from the ventral surface of the metoptic root towards the optic foramen. This process escapes attention when seen from the dorsal surface and is visible only on close examination from the lateral view. It is at the initial stage of development.

In Lepus, de Beer (1930), the ala hypochiasmatica develops as an isolated piece of cartilage attached to the preoptic root of the ala orbitalis before the former is fused to the central stem. At a later stage of development the preoptic root joins the central stem, posterior to the lamina orbito-nasalis and with it the ala hypochiasmatica joins the central stem posteriorly, thus enclosing a small foramen known as the prechiasmatic foramen. This cartilage is also known as the paroptic process.

The ala hypochiasmatica was found for the first time in mammals (Lepus) by Voit in 1916. It has been found in many species of which a few examples are Homo (Kernan 1916), Tatusca (Fawcett 1921), Microtus (Fawcett 1917), Canis (Olmstead 1911), Sus (Mead 1909), Bos (Fawcett 1918 A) and Equus (Arnold 1928).

In some forms the ala hypochiasmatica is attached to the preoptic root of the ala orbitalis as in Lepus, de Beer (1930), Voit (1916), whereas in others to the metoptic root, with the result it projects from the central stem on either side and forms the ventral border of the optic foramen. Examples of mammals in which the ala hypochiasmatica is attached to the metoptic root are Ovis, Canis, Sus, Bos, Equus, Homo, etc. de Beer (1929).

In the ethmoid region the lamina orbito-nasalis is more advanced in its development than in the previous stage. Though all three cartilages which go to form the ethmoid region are chondrified as evidenced by the deep staining these cartilages have taken, the anterior part of the parietotectal cartilage is unstained and hence the details are wanting (Fig. XXVII).

The nasal septum, the medial partition between the two nasal capsules, which is the continuation of the trabecula, increases in height gradually from the point in front of the preoptic root of the ala orbitalis, reaching its highest point towards the fenestra olfactoriae where the parieto-tectal cartilages are attached. Consequently the dorsal border of this part of the nasal septum is slanting, facing the cerebral part of the cranium. From its highest point the nasal septum gradually decreases in height, as it reaches the level of the fenestrae narinae. The septum is thick at the ventral border with the exception of the anterior end. Viewing the septum ventrally it is like a thick rod tapering towards the anterior end (Figs. XXIV, XXV).

In the pig (Mead 1909, Parker), there is a thin place in the nasal septum a short distance from the fenestrae narinae. In Talpa (Fischer) there is no cartilage at this point and the gap is filled with connective tissue. Similarly in Canis, Echidna and Erinaceus, there is absorption of the cartilage to a greater or lesser extent in the nasal septum, a short distance from the anterior nasal opening. Spurgat (1896) considers this absorption of cartilage in the nasal septum, as an adaptation in mammals, where the snout is more movable. No such gap or thinning of the nasal cartilage is found in Ovis.

From the dorsal edge of the nasal septum, the parietotectal cartilages grow out, first upwards and then take a curve forwards and downwards forming the roof and side wall of the anterior part of the ethmoid region. These parietotectal cartilages are in the form of scrolls on either side of the septum, extending from the highest point of the nasal septum to the anterior extremity. The dorsal edges of the parietotectal cartilages join the nasal septum in such a way as to form a long furrow all along the dorsal border of the nasal septum, from the anterior to the posterior extremity. This groove is known as the sulcus supraseptalis. Such a groove is found in the ethmoid region of the pig (Mead 1909), Bos (Decker) and Cattle (Strum) as well. The postero-dorsal angles of the parietotectal cartilages project backwards forming a process known as the crista galli. While the anterior border of the parietotectal cartilage forms the aperture of the fenestra narina, the posterior border projects into the nasal cavity. The ventral borders of the parietotectal cartilages curve downwards and inwards leaving the nasal capsule open ventrally (Fig. XXIX).

The next segment to chondrify in the ethmoid region is the paranasal cartilages. These are in the form of two globular structures, situated posterior to the parietotectal cartilages. The paranasal cartilages chondrify from a separate point in such a way that they overlap the posterior edges of the parietotectal cartilages anteriorly and the anterior edges of the next segment, namely the lamina orbito-nasalis (planum antorbitale) posteriorly. Consequently the posterior edges of the parietotectal cartilages project into the nasal cavity in the form of ridges, known as the crista semicircularis, and the anterior borders of the lamina orbito-nasalis project as the first ethmoturbinals, inside the nasal cavity. That the paranasal cartilages chondrify separately and become attached to the parietotectal cartilages is proved by the fact that the fissures between these two cartilages are closed, except for a small foramen dorsally, the epiphanial foramen. This foramen gives passage to the nasal branch of the trigeminus. At the place where the paranasal cartilage joins the parieto-tectal cartilage there is a groove externally known as the sulcus lateralis anterior, opposite to the crista semi-circularis, on the medial side. This groove is seen as a shallow depression, running first obliquely downwards and forwards and later backwards. Similarly, the junction of the posterior border of the paranasal cartilage with the lamina orbito-nasalis is marked by a shallow groove, known as the sulcus lateralis posterior, opposite the first ethmo-turbinal, on the medial side. The globular prominence of the paranasal cartilage is known as the processus maxillaris (Figs. XXVIII, XXVI).

At the postero-dorsal corner of the paranasal cartilages are seen a pair of conical processes, projecting backwards and upwards. This is the beginning of the sphenethmoid commissure which will connect the orbital cartilage with the paranasal cartilage. In Lepus, Sus and other mammals the sphenethmoid commissure is a broad plate of cartilage connecting the nasal capsule with the orbital cartilage, enclosing a foramen beneath the commissure and in between the cartilages known as the orbitonasal fissure. In Ovis the sphenethmoid commissure is represented by a thin conical process in this stage.

In the development of the chondrocranium of cattle (Decker, 1883, Strum 1937) the sphenethmoid commissure is in the form of a conical process projecting from the postero-dorsal corner of the paranasal cartilage. The sphenethmoid commissure in Ovis agrees in shape and position with that of cattle (Fig. XXVI).

The third segment, the lamina orbito-nasalis (planum antorbitale), is the next part of the ethmoid region to chondrify. It extends from the paranasal cartilage, backwards and downwards and curves inwards and forwards at the posterior extremity of the nasal capsule, so as to form the posterior wall known as the cupola posterior, lying close to the nasal septum but free from it (Fig. XXVIII).

Viewing the ethmoid region from the ventral surface a pair of new cartilaginous strips are seen lying on either side of the nasal septum about its middle near the ventral margin, the paraseptal cartilages (Fig. XXIV). The nasal capsule is open ventrally being surrounded by cartilages on all sides, medially by the ventral margin of the nasal septum, laterally by the ventral borders of the parieto-tectal cartilage and the paranasal cartilage, posteriorly by the cupola posterior and anteriorly by the lamina transversalis anterior (unstained in this specimen and therefore not visible). This ventral opening of the nasal capsule is known as the fenestra basalis or choanalis.

Examining the interior of the nasal capsule a number of scroll-like structures are seen attached to the medial surface of the side wall. The ventral margin of the parietotectal cartilage turns inwards on the lateral side of the choanalis as the maxillo-turbinal, extending all along the ventral margin. The posterior border of the parieto-tectal cartilage projects inside the nasal capsule in the form of a curved crest known as the crista semicircularis. Starting from the crista semicircularis is the nasoturbinal extending anteriorly along the middle of the medial surface of the lateral wall longitudinally. At the junction of the paranasal cartilage with the lamina orbito-nasalis, the anterior border of the lamina orbito-nasalis projects into the nasal capsule as the first ethmoturbinal, as stated above. Medial to the first ethmoturbinal develops the second ethmoturbinal. Between the crista semicircularis and the first ethmoturbinal, the paranasal cartilage forms a concave recess known as the recessus frontalis in which rudiments of the frontoturbinal could be seen (Fig. XXVIII).

The parietal cartilages are seen in the procartilaginous stage with ill-defined margins. They are plate-like structures standing in a sagittal plane forming the lateral walls of the cranial cavity. Each plate is attached to the orbital cartilage anteriorly and the supraoccipital cartilage posteriorly. The part of the cartilage which joins the parietal plate with the orbital cartilage is known as the orbitoparietal commissure. By bridging the gap between the orbital and the parietal cartilages the orbitoparietal commissure encloses a big fenestra in the orbito-temporal region known as the sphenoparietal fontanella, through which III, IV, V and VI cranial nerves pass (Fig. XXII).

The broad parietal cartilage with the equally broad orbitoparietal commissure is the homologue of the narrow taenia marginalis of reptiles. The broad nature of this cartilage indicates that it has been inherited from amphibian ancestors, which had a solid side wall and so were of a primitive character. A similar condition has been observed in Sus (Mead 1909) and in Echidna (Gaupp).

The parietal plate is separated from the canalicular part of the auditory capsule by means of the fissure occipito-capsularis superior or parieto-capsularis or foramen jugulare spurium. This fissure is limited anteriorly by the parieto-capsular commissure, which comes in contact with the auditory capsule and posteriorly by the anterolateral extension of the supraoccipital. In this stage the fissure, dorsal to the auditory capsule, is divided into three compartments which are from before backwards, the occipito-capsularis superior, the occipito-capsularis inferior and the jugular foramen. The partition between the last two mentioned being still incomplete (Fig. XXII).

The various commissures have been named according to the parts they connect at different times in the different species. Thus in Lepus (de Beer) the parietal cartilage establishes connection first with the canalicular part of the auditory capsule, forming the parieto-capsular commissure. After the formation of this commissure, the parietal cartilage connects the orbital cartilage with the orbitoparietal commissure. In some forms the orbital cartilage joins the auditory capsule first forming the orbito-capsular commissure and then the orbitoparietal commissure, joining with the parietal cartilage.

In Ovis the parietal plate first connects the canalicular part of the auditory capsule with the parieto-capsular commissure, and the orbital cartilage with the orbitoparietal commissure.

Another interesting feature is the development of the tectum posterius, which forms the posterior roof of the cranial cavity. This is in the procartilaginous stage. The tectum posterius of both sides have already united with each other in the middle line and also with the corresponding supraoccipital cartilages. In all the stages so far described the posterior part of the roof of the cranial cavity was open, since the tectum posterius was not formed (Fig. XXI).

In the otic region the auditory capsule shows clearly the two parts of which it is constituted, namely the canalicular part and the cochlear part. In the stages so far described only the canalicular part could be seen stained as a more or less oval-shaped structure, whereas the cochlear part was visible as an unstained transparent body. Close examination of the otic region reveals many interesting features. The canalicular part of the auditory capsule is fully chondrified, whereas in the cochlear part only the outlines are visible indicating the outer boundary. The cochlear part is relatively smaller than the canalicular part and lies anteriorly and medially to the canalicular part. So far the auditory capsule has been observed as an isolated cartilage situated anterior to the occipital arches. For the first time, in the stage under consideration, the auditory capsule is seen anchored to the basal plate by means of two commissures, the anterior and the posterior. The anterior commissure is also known as the sphenocochlear commissure in mammals, which stretches from the anterior part of the cochlear capsule to the antero-lateral corner of the basal plate, thus forming the posterior boundary of the carotid foramen. The posterior commissure is known as the basivestibular commissure. It stretches from the posterior part of the cochlear capsule to the postero-lateral corner of the basal plate. In between these two commissures is a long fissure separating the auditory capsule from the basal plate known as the basicochlear fissure (Fig. XXIII).

The anterior and posterior commissures are also known as the anterior basicapsular commissure (sphenocochlear commissure) and the posterior basicapsular commissure (basivestibular commissure) respectively (Gaupp 1900 and 1906a). The anterior basicapsular commissure is always joined to the basal plate behind the facial nerve, whereas the posterior basicapsular commissure varies in its position. In some forms (like Salmo, Amia, Solea, etc.) the posterior basicapsular commissure joins the parachordals, posterior to the glossopharyngeal and in front of the vagus nerve. By such an attachment a portion of the fissura metotica, in which the glossopharyngeal nerve is situated, is incorporated into the basicochlear fissure.

In amniotes, the posterior basicapsular commissure joins the parachordals anterior to the glossopharyngeal and vagus nerves. To draw a distinction between these two types of attachments, the posterior basicapsular commissure in amniotes has been called the basivestibular commissure, which is the common type in almost all the mammals.

The posterior commissure in Ovis is of the basivestibular type, being attached to the basal plate anterior to the glossopharyngeal and vagus nerves and is fully in agreement with that of other mammals.

The alicochlear commissure is beginning to make its appearance in the form of a small procartilaginous projection on the anterior part of the cochlear capsule. On account of the auditory capsule projecting towards the basal plate, the latter is gracefully curved with concave borders and as a result of this the central portion of the basal plate is the narrowest part (Fig. XXIII).

In the splanchno skeleton many new and interesting features are visible. The Meckel's cartilage is still separated from the fellow of the opposite side in the anterior region. The posterior extremity is still in the procartilaginous stage as indicated by the light staining it has taken. The bent portion of the Meckel's cartilage forms the manubrium of the future malleus. The incus is in the same shape and position as that of the previous stage, (Fig. XXII).

The laterohyal and the stylohyal cartilages have now definitely chondrified and are joined together to form the Reichert's cartilage. The dorsal extremity of the Reichert's cartilage is still separated by means of a narrow gap from the crista parotica of the auditory capsule. It is directed downwards, forwards and inwards and near its anterior extremity is seen the ceratohyal, which is in the form of an unstained and transparent short rod. Below the ceratohyal there is a short stumpy cartilage, the hypohyal, one end of which is attached to a transversely placed basihyal. The basihyal is seen as a thin rod running transversely and connecting the hypohyal of one side with that of the opposite side. Attached to the latero-posterior corner on each side of the basihyal is the thyrohyal cartilage which is directed backwards and upwards as a thin curved rod.

The two alae of the thyroid cartilage are united in the middle and are widely separated at the dorsal extremity. The cricoid cartilage is seen as a semicircular ring. The arytenoid cartilages have not yet appeared (Fig. XXX).

Stage X

(Figs.XXXI, XXXII, XXXIII, XXXIV).

C 2 - 28 mm. C.R.L.

There is not much change in the central stem in this stage. In the region of the central stem the only feature which draws attention is the reduction in length of the notochord to a short rod, situated in the centre surrounded by deeply stained cartilaginous tissue (Fig. XXXI).

The cochlear part of the auditory capsule is anchored to either side of the central stem by means of the spheno-cochlear commissure anteriorly and the basivestibular commissure posteriorly. These two commissures enclose a curved space, the basicochlear fissure, with the basal plate on the medial side gracefully curved and the cochlear part of the auditory capsule on the lateral side. The ali-cochlear commissure which extends from the anterior part of the cochlear capsule has joined the processus alaris, thus enclosing a foramen, the carotid foramen for the passage of one of the branches of the internal maxillary artery which in turn is a branch of the external carotid artery (Fig. XXXI). The hypoglossal foramina are double on each side of the notochord as in the previous stage. The hypophyseal cartilage and the nasal septum, with its attachment of the cartilages of the nasal capsule are in the same state of development as that of the previous stage.

The ala hypochiasmatica attached to the metoptic root of the ala orbitalis is better developed and projects like a process into the optic foramen (Fig. XXXII).

Only the posterior cartilages in the ethmoidal region have taken the stain as in the previous stages, and so the details of the anterior region are still wanting. Careful examination of this region reveals some of the structures in a transparent form which indicates that they have formed but no reason could be attributed for the non-staining property of these parts. Transverse serial sections of an embryo of the same age reveal, on staining with the usual stains, namely haemotoxylin and eosin, the cartilaginous framework of the anterior region and a detailed description of this will be taken up at a later stage of development.

The orbitoparietal commissure is still in the procartilaginous stage. The chondrification of the cochlear part has advanced further in the otic region and consequently some of the foramina of the auditory region are clearly perceptible.

The auditory capsule besides being anchored to the central stem by the cochlear part is also attached to the side wall of the chondrocranium by the canalicular part. The occipito-capsular fissure is divided into the occipito-capsularis superior, the occipito-capsularis inferior and the jugular foramen, the partition between the last two mentioned being still in formation (Fig. XXXIII).

The auditory capsule is divided into two parts, namely the pars cochlearis, including the cochlear duct and the saccule, and the pars vestibularis, enclosing the semicircular canals with their ampullae and the utricle. The cochlear part extends from the anterior margin of the occipital region as far as the posterior border of the hypophyseal cartilage and is the smaller of the two parts of the auditory capsule. It is situated medially and ventrally to the canalicular part, forming part of the floor of the cranial cavity. The canalicular part is like an equilateral triangle with the angles rounded off and is attached to the cochlear part by one of the sides of the triangle. The medial surfaces of the cochlear and the canalicular parts are concave in their transverse direction and are in accordance with the general concavity of the cranial cavity and form, in this stage, part of the floor and side wall of the cranial cavity. The semicircular canals are visible as transparent tubes and their position can be easily recognised. The lateral semicircular canal projects ventro-laterally and gives rise to the crista parotica, which runs in an antero-posterior direction on the lateral side of the canalicular part. Anteriorly the crista parotica becomes a small process, the tegmen tympani. The mastoid process has not yet appeared. Ventral to the crista parotica, at the junction of the cochlear and the canalicular part laterally is the foramen ovale into which the foot-plate of the stapes fits (Fig. XXXIII).

The medial surface of the fully chondrified auditory capsule shows some gaps of considerable size. Describing these foramina from behind forwards, there is a longitudinal foramen running in a transverse direction near the posterior third of the auditory capsule at the junction of the canalicular part with the cochlear part. This is the foramen endolymphaticum for the passage of the endolymphatic duct but it has not yet attained its final shape and size. Near the anterior part of the junction of the two parts of the auditory capsule is the oval-shaped foramen acusticum, anterior to which is seen a thin bridge of cartilage extending from the anterior wall of the canalicular part to the dorsal wall of the cochlear capsule. This bridge of cartilage is known as the prefacial commissure, which encloses the primary facial foramen through which the facial nerve passes out of the auditory capsule. At the posterior surface of the cochlear part of the auditory capsule just below the canalicular part is an oval-shaped foramen, the foramen perilymphaticum. There is no indication as yet of the formation of the processus recessus and so the fenestra rotunda and the aquaeductus cochleae cannot be identified.

In the splanchno skeleton all the cartilages described in the previous stage, namely the Meckel's cartilage, incus, stapes, Reichert's cartilage, thyroid cartilage, cricoid cartilage and the cartilages of the hyoid apparatus are present in the same state of development.

Stage XI.

Figs. XXXV, XXXVI, XXXVII, XXXVIII, XXXIX, XL, XLI, XLII, XLIII, XLIV, XLV, XLVI, XLVII, LII, LIII, LVI, LVII, LX, LXI, LXII, LXV, LXVI, LXVIII, LXX, LXXII.

Plates. XLVIII, XLIX, L, LI, LIV, LV, LVIII, LIX, LXIII, LXIV, LXVII, LXIX, LXXI, LXXIII, LXXIV, LXXV, LXXVI, LXXVII, LXXVIII, LXXIX, LXXX, LXXXI, LXXXII, LXXXIII, LXXXIV, LXXXV, LXXXVI, LXXXVII, LXXXVIII, LXXXIX, XC, XCI.

G 6 - 19 mm. H.H., G 28 - 22mm. H.H., G 20 - 24 mm. H.H., G 13 - 25 mm. H.H., E 12 - 27 mm. H.H., H 5 - 37 mm. H.H.

The development of the chondrocranium has so far been traced from the early stages but the stage now under description has been chosen to represent the fully formed chondrocranium. A wax model of the anterior portion of the nasal capsule has been prepared to show the relationship of the various cartilages (Plates LXIII, LXIV). Different methods have been adopted to describe the fully developed chondrocranium, the most common one, which was followed by many of the previous workers in this field of study, consists of dividing the skull transversely into a number of regions, namely, occipital, otic and sphenoid, each of which is treated separately. Fawcett (1917) evolved an entirely new method of describing the chondrocranium dividing it into - I. The central stem, II. Structures appended to each side of the central stem, III. The lateral structures, IV. The lateral commissures, and V. Structures forming the roof. Fawcett's method will be followed here as it is easier to convey the relationships of the various constituents of the chondrocranium and to give a better impression of the development.

At this stage of development, the chondrocranium is fully formed and is in the form of a pear with a narrow anterior end and a broad posterior extremity. The large size of the brain, which is characteristic of all mammals has pushed the brain case forward, with the result the cribriform plate has assumed a horizontal position from its primitive vertical position. The brain case of the chondrocranium is open dorsally except for the posterior region where it is covered by the tectum posterius. In the later development of the cranium the roof is closed by the membrane bones, namely the frontals and the parietals. The side wall of the cranium is formed from the anterior to the posterior extremity by the broad plate-like cartilages of the ala orbitalis, the commissura orbito-parietalis and the parietals on each side, which are upstanding in position. The broad nature of the side wall is considered to be a primitive character inherited from prereptilian ancestors, namely the amphibians, which had a solid side wall, whereas the side wall of the chondrocranium of reptiles is narrow and is known as the taenia marginalis (Gaupp 1900).

The ethmoid region is bent at an angle to the rest of the cranium and the length of the nasal region is moderately proportional to the rest of the cranium. All the cartilages in this stage are fully formed and neither the line of demarkation nor the histological differentiation, at the junction of the various constituents, which have fused together, can be seen. Moreover none of the cartilages have yet begun to ossify. The mandibular, hyoid and branchial arches complete the floor of the pear-shaped contour of the chondrocranium.

I. The Central Stem

The central stem extends from the anterior margin of the foramen magnum to the tip of the nose and is made up of the following parts - a) the pars chordalis (basal plate), b) the pars trabecularis (the polar plate of Noordenbos), and c) the pars interorbito-nasalis or interorbito-nasal septum. A part of this portion lies between the optic foramen and is continued further as the nasal septum.

a) The pars chordalis.

The pars chordalis is also known as the basal plate since it covers the cranial portion of the notochord. It extends from the anterior margin of the foramen magnum up to the hypophyseal cartilage. With the exception of the nasal septum the central stem is a horizontal plate, forming the base of the brain case. The nasal septum is a thin vertical plate dividing the nasal capsule into two equal parts. The basal plate is narrow and sub-cylindrical anteriorly and is broad and quadrilateral posteriorly where it joins the occipital arches. The lateral margins are concave and are gracefully curved due to the extension of the cochlear part of the auditory capsule. The anterior part is a littler broader and boss-like where it joins the hypophyseal cartilage. The middle portion is the narrowest part due to the extension of the cochlear part of the auditory capsules which compress the cartilaginous basal plate lying between them. The basal plate is separated from the auditory capsule by means of the basicochlear fissure. The posterior margin of the quadrilateral basal plate forms the anterior boundary of the foramen magnum, and the anterior margin, the posterior boundary of the foramen jugulare (fissura metotica). The postero-lateral angles of the basal plate fuse with the occipital arches and the hypoglossal foramen lies at the junction of these two cartilages for the exit of the roots of the hypoglossal nerve. There is a pair of hypoglossal foramina situated on either side of the notochord in an antero-posterior direction. A line drawn through these foramina in an antero-posterior direction indicates the lateral limit of the basal plate. The cartilages lateral to this line belong to the occipital arches. It has been observed in the present investigation, that in almost all the specimens of sheep examined there is a pair of hypoglossal foramina on either side of the notochord, which persist even in the well advanced stage of development of the chondrocranium (Fig. XXXV).

In Lepus, Voit found two hypoglossal foramina on each side of the notochord, which persist even in the adult skull. The number of these foramina on each side may not only vary in a single genus but also in the species. Fischer observed two hypoglossal foramina on the left side and three on the right side in an embryo of Semnopithecus pruinosus, whereas in Semnopithecus maurus he found a single foramen on each side. Posterior to the hypoglossal foramen the basal plate passes on to the occipital arches without any line of demarkation. The cranial surface of the occipital part of the basal plate is concave, whereas the ventral surface of the entire plate facing the pharynx is convex from side to side. Anteriorly the basal plate gradually rises forming the crista transversa, a vertical plate of cartilage running across the basal plate, thus limiting the posterior boundary of the sella turcica, situated in the hypophyseal cartilage.

In the present investigation the following course of the cranial part of the notochord was observed in Ovis. In the very early stage of development of the chondrocranium the notochord has been observed to develop dorsally, just beneath the perichondrium with greater thickness of the caudal edge of the basal plate beneath it. In other words it may be mentioned that the parachordal plates were hypochordal in position. Similar observations were made in Cat (Terry 1917), Sus (Mead 1909), Lepus (de Beer 1930).

The notochord has completely degenerated in the fully formed chondrocranium and no trace of it is seen, either in the total mass staining of the specimens by the Van Wijhe method, or in the transverse serial sections of specimens of the same size and age. The course of the notochord has been studied in one of the developing chondrocranium. Its thickness varies at different levels of the parachordals and tracing the course from the caudal region of the basal plate, it is found to be just beneath the perichondrium of the basal plate in this region. It gradually dips into the thickness of the basal plate as it extends forwards, lying almost mesially and also midway between the cranial and the pharyngeal portion of the basal plate. After coursing some distance this way, the notochord bends ventrally towards the pharyngeal surface of the basal plate and then finally leaves the basal plate to find its position in the dorsal wall of the pharynx, where it is slightly enlarged. As previously observed the thickness of the notochord is not uniform throughout its course. It is composed of a group of mesenchymal cells surrounded by a layer of similar cells (Fig. XXXVI).

It is interesting to note in Ovis that the course of the notochord is entirely different from what has been observed in other mammals. In Lepus, de Beer (1930) found the notochord conforming to the type which Block (1922) called transbasal; that is the notochord runs dorsally in the hindmost part of the basal plate and then pierces it ventrally, to run some distance on the ventral surface. It again penetrates the basal plate to run embedded in the thickness of its anterior part.

In Sus, Mead (1909) observed the notochord leaving the basal plate in the middle of its course to enter the dorsal surface of the pharynx. It then re-enters the basal plate to course itself to the anterior region, so as to lie just beneath the perichondrium of the floor of the hypophyseal cartilage. He also observed the cranial and the caudal swelling of the notochord.

Terry (1917) in his investigation of the development of the chondrocranium of the cat observed that the notochord lies just beneath the perichondrium with the mass of the posterior portion of the basal plate underneath it. It then extends forward in the middle of the basal plate but does not reach the ventral surface of the basal plate nor the dorsal surface of the pharynx at any stage. The notochord bends abruptly at the level of the dorsum sellae to lie beneath the perichondrium of the caudal surface of the sella turcica.

The present investigation of the development of the chondrocranium of Ovis evinces two interesting points regarding the course of the notochord, namely (i) it is not transbasal, and (ii) there is no break in its course till it reaches the dorsal surface of the pharynx.

The chondrification of the basal plate is complete in this stage. It is related anteriorly to the hypophyseal cartilage, antero-laterally to the sphenocochlear commissure, laterally to the basicochlear fissure and postero-laterally to the occipital arches. It is connected to the cochlear part of the auditory capsule by means of the sphenocochlear commissure anteriorly and the basivestibular commissure posteriorly.

(b) The pars trabecularis.

The hypophyseal cartilage is situated anterior to the parachordals and is associated with the pituitary body. In the early stages of development, the hypophyseal cartilage is seen to chondrify from two centres, one situated on the right and the other on the left side of the future hypophyseal foramen, through which the hypophyseal duct passes. As development advances, these two centres of chondrification extend all round the duct with the result the hypophyseal foramen is found piercing the plate-like cartilage. This foramen disappears in the later development of the chondrocranium. The extent of the hypophyseal cartilage may be determined by drawing an imaginary line both anteriorly and posteriorly. The anterior extent of the cartilage is determined by drawing a transverse line through the hinder edges of the metoptic roots of the ala orbitalis, whereas the posterior limit is shown by the transverse line drawn through the anterior wall of the basicochlear fissure.

The lateral margins of the hypophyseal cartilage extend from the metoptic roots of the ala orbitalis to the anterior wall of the basicochlear fissure. The lateral margin bears the sphenocochlear commissure posteriorly (the posterior trabeculo-cochlear commissure) which separates the basicochlear fissure from the foramen caroticum for the passage of one of the branches of the internal maxillary artery, thus forming the posterior boundary of the carotid foramen. The sphenocochlear commissure extends

extends from the anterior margin of the cochlear part of the auditory capsule to the antero-lateral margin of the parachordals. Near the posterior third of the lateral margin of the hypophyseal cartilage another process, the basitrabecular or the alar process (the anterior trabeculocochlear commissure) extends outwards anterior to the above mentioned artery, thus forming the anterior boundary of the carotid foramen. The carotid foramen is completed laterally by the alicochlear commissure which extends from the anterior margin of the cochlear part of the auditory capsule to the alar process. The remaining two-thirds of the lateral margin of the hypophyseal cartilage, anterior to the alar process, is free and forms the medial border of the spheno-parietal fontanella.

The hypophyseal cartilage is flattened dorso-ventrally and presents two surfaces for description, namely, the dorsal or caval surface and the inferior surface. The dorsal surface bears a depression known as the sella turcica in which the pituitary body is lodged. The sella turcica is deep posteriorly and becomes shallow gradually in the anterior region. It is limited behind by the crista transversa which runs across the anterior part of the parachordals in the form of a conical vertical plate. Anteriorly the fossa is limited by the tuberculum sellae, a raised prominence situated in the region of the metoptic roots of the ala orbitalis. The ventral surface is slightly convex from side to side and has no keel-like structure as found in some of the mammals. The thickness of the cartilage increases gradually from the posterior to the anterior surface where the tuberculum sellae is situated (Fig. XXXVII).

(c) <u>The pars interorbito-nasalis.</u>

A part of this cartilage lies between the optic foramen, and the rest of it continues forward as the nasal septum. Its posterior extent is indicated by an imaginary line drawn through the posterior margins of the metoptic roots of the ala orbitalis. This cartilage is quite thick in the region of the metoptic roots, due to the presence of the tuberculum sellae. Anterior to the tuberculum sellae there is a slight depression, the fossa chiasmatica, which lodges the optic chiasma. The fossa chiasmatica is bounded anteriorly again by a rise of the dorsal surface of the central stem which continues forward as the vertical nasal septum. A small portion of this vertical plate lies behind the nasal capsules separating the orbits from one another and the term interorbital septum is applied to this part. The interorbital septum is feebly developed in Ovis as in Bos and Sus (Fig. XXXVIII).

The ventral surface is strongly convex from side to side and there is no keel-like projection as is found in reptiles and birds. The keel-like ventral projection of the interorbito-nasalis in birds and reptiles is mainly due to the large size of the eyes, forcing the lateral walls of the brain case more and more together, till only a vertical plate remains between the eyes. In mammals the keel has been obscured by the large size of the brain which presses the cartilage from above and the formation of the secondary palate which limits the ventral extent of the cartilage.

The nasal septum is the anterior continuation of the interorbital septum, the one passing into the other gradually without any line of demarkation. The nasal septum may be divided into two parts, namely, the subcerebral and the precerebral parts. The subcerebral part measures nearly one third and the precerebral part two thirds of the total length of the nasal septum. The subcerebral part rises gradually in height until at its anterior end it terminates in a small backwardly curved process known as the crista galli. The subcerebral part extends in an almost horizontal plane from its primitive vertical position in lower forms. Both the subcerebral and the precerebral parts of the nasal septum are inclined to one another with the convex angle above (Fig. XXXIX).

Posteriorly the lateral borders of the nasal septum bear the lamina orbito-nasalis and the lamina cribrosa extends outwards from the remainder of the lateral margin. The upper border of the nasal septum, from the crista galli forward, is the precerebral part and it lies in a longitudinal groove known as the sulcus supraseptalis. The sulcus supraseptalis extends throughout the entire length of the nasal capsule in Ovis, as in Homo, Lepus, Bos and Sus (Fig. XL, Plates, LXXIII, LXXIV).

The inferior border of the nasal septum forms an obtuse angle with the posterior part of the central stem. This border is thicker than the superior border and is convex from side to side. It is free for the most part and is connected a little distance from the anterior end to the lamina transversalis anterior and posteriorly to the lamina orbito-nasalis. Between these two connections the inferior border of the nasal septum is in close relationship on each side with the paraseptal cartilage and the lamina transversalis posterior with a narrow septo-paraseptal fissure intervening. There is no perforation of the nasal septum as is found in Sus (Mead 1909).

II. <u>Structures appended to each Side of the Central Stem</u>

These structures are from behind forward -

a) the exoccipital cartilage,

b) the auditory capsule,

c) the ala temporalis,

d) the ala orbitalis,

e) the lateral nasal capsule.

a) <u>The exoccipital cartilage</u>.

The exoccipital cartilages extend from the postero-lateral angles of the basal plate. The chondrification is complete and so there is no line of demarkation at the junction of the basal plate with the exoccipitals, except for the hypoglossal foramina of which there are a pair on each side, consisting of a smaller anterior and a larger posterior foramen. A line drawn through these foramina in an antero-posterior direction will indicate the lower limits of the exoccipitals. The ventral surface of the exoccipitals lateral to the hypoglossal foramina projects out from the general surface of the skull to form the occipital condyles. There is a pair of condyles, one on each side of the foramen magnum, well separated from each other and directed downwards, backwards and outwards, articulating with the atlas (Fig. XLI).

The anterior margin of the exoccipital projects under the pars canalicularis of the auditory capsule as a thin sheet of cartilage known as the lamina alaris, but is separated from the cochlear part of the auditory capsule by the foramen jugulare. The lamina alaris projects under the canalicularis in such a way that a narrow space is left between the two, the recessus supra-alaris which lodges the sigmoid sinus. The recessus supra-alaris is visible only from the caval surface as a certain amount of fusion takes place superficially between the lamina alaris and the canalicularis. The anterior margin of the exoccipital from the region of the lamina alaris extends ventrally in the form of a process known as the paracondylar process, which is regarded as the transverse process of a vertebral element incorporated in the skull. The anterior border of the lamina alaris arching over the posterior border of the canalicularis of the auditory capsule establishes contact with it in such a way that two fissures are separated; namely the inferior occipito-capsularis or the foramen jugulare and the superior occipito-capsularis or the parieto-capsularis from the otherwise single occipito-capsularis of the early stages (Fig. XLII).

The more ventral part of the occipitals may be considered as a three-sided mass in cross section. The anterior angle is directed forwards and outwards, the lamina alaris is extended ventrally as the paracondylar process, the posterior angle extends downwards, backwards and outwards as the occipital condyles which articulate with the atlas. The medial angle is directed inwards, passing without any line of demarkation into the basal plate. The external surface of the exoccipital cartilage is convex and the internal or the caval surface is concave.

The posterior margin of the exoccipitals forms the anterior boundary of the foramen magnum. The foramen magnum in the stage under description is surrounded by cartilage on all sides which forms a ring except the dorsal part where a small gap is left. The foramen magnum may be described as having a vault, two sides and a floor. The vault is formed by the tectum posterius, a thin plate of cartilage which connects the supraoccipitals of each side above the brain. The anterior part of the tectum posterius has fused in the mid dorsal line, forming a continuous sheet of thin cartilage connecting the supraoccipitals with each other as mentioned above. The posterior part of the tectum posterius is still separated by means of a narrow slit (Fig. XLIII).

This condition clearly indicates that the tectum posterius is of double origin in Ovis, one on each side of the mid dorsal line and as chondrification advances they unite in the mid dorsal line. It may be recalled that the cranium has a cartilaginous roofing only in the posterior region formed by the tectum posterius and the rest of the cranium is open dorsally. The cranium is roofed by the membrane bones; the frontals and the parietals. Each exoccipital joins the supraoccipitals of its side dorsally. The line of fusion between these two was clearly indicated in the earlier stages of the development of the chondrocranium. The specimen under description shows no line of demarkation between these two cartilages.

b) The auditory capsule.

The auditory capsules are situated in the otic region, which extends from the posterior border of the auditory capsule forward to the sella turcica. The auditory capsule is divided into two main sub-divisions, the pars cochlearis containing the saccule and the cochlea and the pars canalicularis in which the utricle and the semicircular canals are situated. The pars cochlearis can be further subdivided into a vestibular and a cochlear segment. The shape of the auditory capsule is moulded according to the structures contained therein. The axis of the capsule is similar to that of the basal plate except that it is inclined obliquely outwards in a postero-anterior direction. The pars canalicularis is situated dorsally and posterior to the cochlear part which lies ventrally. The auditory capsules are pushed from above downwards by the greater development of the brain in mammals, with the result the capsules form the floor of the brain case rather than the side wall as in some of the primitive forms. The pars cochlearis extends downwards and forwards medially, compressing the basal plate, which lies between the capsules. Hence the narrowest width of the basal plate lies between the auditory capsules (Plate LXXXII).

The auditory capsule is anchored to the neighbouring parts of the chondrocranium by means of various commissures. Enumerating the commissures which connect the cochlear part of the auditory capsule to the basal plate from the front backwards, they are - the alicochlear commissure (anterior trabeculo-cochlear), this extends from the anterior end of the auditory capsule to the processus alaris (basipterygoid process), external to the carotid foramen, forming the lateral boundary of the carotid foramen. The second commissure is the sphenocochlear commissure (posterior trabeculo-cochlear) which connects the cochlear part to the antero-lateral angles of the basal plate, forming the posterior boundary of the carotid foramen. The third commissure, the basivestibular commissure (chordo-cochlear commissure) connects the posterior part of the cochlear capsule to the parachordals and separates the basicochlear fissure from the foramen jugulare behind. It connects the cochlear part of the auditory capsule to the parachordals in front of the glossopharyngeal nerve, whereas in the lower forms it joins behind this nerve and is known as the posterior basicapsular commissure (Fig. XXXI).

The pars canalicularis is connected to the side wall of the cranium by means of the following commissures. Describing them from the anterior to the posterior region they are, the parieto-capsular commissure, which connects the parietal cartilage to the anterior part of the auditory capsule thus limiting the superior occipito-capsular fissure anteriorly and separating it at the same time from the sphenoparietal fontanella. The second is the occipito-capsular commissure which extends from the antero-lateral angle of the supraoccipital cartilage to the posterior cupola of the canalicular part of the auditory capsule. This commissure forms the posterior boundary of the superior occipito-capsular fissure. The third commissure is established between the posterior margin of the canalicular part and the lamina alaris which separates the foramen jugulare from the inferior occipito-capsular fissure (Figs. XLVII, Plate XLVIII).

The pars canalicularis contains the utricle and the semicircular canals. The shape of this part is influenced by the structures contained therein, especially the semicircular canals. It is in the form of a pyramid or an equilateral triangle with the angles rounded off. The borders of the pyramid are prominent due to the projection of the semicircular canals which run in the interior. From their position these borders may be termed, anterior, posterior and lateral (Fig. XLIV, Plates LXXXII, LXXXIX).

The anterior border starts from the dorsal angle of the triangle and ascends in an arched fashion in a forward direction. It terminates in a depression followed by a prominence caused by the tegmen tympani. The tegmen tympani starts from the anterior angle of the canalicularis and becomes fused with the lateral wall of the cochlear capsule enclosing a foramen known as the secondary facial foramen through which the facial nerve passes. The tegmen tympani is also known as the lateral prefacial commissure. The stage under description shows the tegmen tympani in the form of a process still unconnected to the lateral wall of the cochlear capsule. The anterior border is slightly prominent and is known as the prominentia semicircularis anterior. This is caused by the projection of the anterior semicircular canal contained in it. This border carries the parieto-capsular commissure in the middle and the occipito-capsular commissure at the dorsal extremity. Below the attachment of the parieto-capsular commissure the anterior border forms the posterior boundary of the sphenoparietal fontanella, which is the largest lateral fissure of the developing chondrocranium. The border between the parieto-capsular commissure and the occipito-capsularis forms the lower boundary of the superior occipito-capsularis fissure (Fig. XLIV, Plate LXXXIX).

The posterior border starts like the anterior, from the dorsal angle of the triangle, and descends in an arched manner backwards till it reaches the posterior angle. The lamina alaris is attached to this border separating the foramen jugulare from the inferior occipito-capsularis fissure. The lamina alaris fuses with the posterior border in such a way that it encloses a recess, the recessus supra-alaris which lodges the sigmoid sinus, only visible from the caval surface of the cranium. The greater part of the posterior border is fused with the lamina alaris and a small portion forms the lower boundary of the inferior occipito-capsularis fissure. The prominence caused by the posterior semicircular canal is greater than the anterior and is known as the prominentia semicircularis posterior. The prominentia semicircularis lateralis commences at the lower extremity of this prominence (Fig. XLIV, Plate XC).

The lateral border forms the base of the triangle and carries a number of interesting features. It is the most prominent of the three borders and is known as the prominentia semicircularis lateralis. This border overhangs that of the cochlear capsule forming a thick ridge called the crista parotica which runs in an antero-posterior direction. The sulcus facialis is a longitudinal groove running ventrally between the crista parotica and the cochlear capsule. The facial nerve courses backwards in this groove. The crista parotica projects over the stapes and incus and the crus breve of the latter is attached to it. Tracing the crista parotica from anterior to posterior the following details are observed. Anteriorly it extends to form the tegmen tympani which fuses with the lateral wall of the cochlear capsule giving rise to the secondary facial foramen through which the facial nerve passes. Behind the tegmen tympani there is a notch which is the outer end of the fossa incundis in which the crus breve of the incus is lodged. Posterior to this notch and about the middle of the ridge the proximal extremity of the Reichert's cartilage is fused and behind its root there is a notch through which the facial nerve emerges out of the sulcus facialis to wind round the cartilage. Posterior to this notch the crista parotica shows a slight projection foreshadowing the formation of the mastoid process and then it joins the paracondylar process posteriorly, which is the ventral continuation of the lamina alaris (Fig. XLIV, Plates LXXXVI, LXXXV, LXXXVII, LXXXVIII).

The lateral surface of the pars canalicularis is triangular in form with the base directed downwards and forwards and attached to it is the pars cochlearis. The sides of the triangle are formed, as already stated, respectively by the prominentia semicircularis anterior, prominentia semicircularis posterior and the prominentia semicircularis lateralis, the posterior and lateral being the best developed. Between these prominences the lateral surface of the capsule sinks from the general contour, and a shallow depression, the fossa subarcuata external is noticed in the triangular hollow.

The medial surface like the lateral is triangular in form. The base of the triangle is continuous with the cochlear capsule without any line of demarkation between them. In general the medial surface is uneven and with the cochlear part forms a concave surface directed transversely downwards and forwards, forming a part of the floor of the cranium. The ventral position of the auditory capsule, from its primitive vertical position, is due to the downward pressure exerted by the developing brain which has attained a greater size in most mammals. Anteriorly the medial surface is marked off by the anterior semicircular canal, but it is not so prominent as on the lateral side. Immediately behind the anterior border is seen a wide shallow depression, the fossa subarcuata anterior interna. In the early stages of development, a small perforation due to deficiency of cartilage is observed in the dorsal region of the fossa subarcuata anterior interna which disappears as development advances. A slight elevation is observed below this fossa in the anterior region and it is known as the prominentia utriculo-ampularis anterior. The foramen endolymphaticum is seen behind the fossa and below the crus commune, which is distinctly visible in the now transparent whole mass stain. The endolymphatic duct of the membranous labyrinth passes out from the interior of the auditory capsule through this foramen. During the early stages of development of the chondrocranium the foramen endolymphaticum is observed in the form of a longitudinal gap running in a transverse direction (Fig. XXXIV). This gap becomes reduced gradually as development advances and attains its final oval shape. Posterior to the crus commune which divides the medial surface of the canalicular part of the auditory capsule into two unequal parts by means of a slightly elevated ridge, is the fossa subarcuata posterior interna. Below and behind this fossa is a prominence, the prominentia utriculo-ampularis posterior. The basal region of the canalicular part may be considered as partly free and partly fused with the pars cochlearis. The free portion is in the anterior region extended in the form of a process, the tegmen tympani from the anterior angle of the triangle. The tegmen tympani starts from the ventral surface of the base of the triangle and joins the lateral surface of the pars cochlearis enclosing the secondary facial foramen through which the facial nerve passes outward to the sulcus facialis situated on the ventral face of the crista parotica. The rest of the basal part of the pars canalicularis is fused with the pars cochlearis (Figs. XLV, XLVII, Plate XCI).

Of the two parts of the auditory capsule the pars cochlearis is the smaller in size. It is a dome-shaped capsule directed downwards and forwards. The anterior end or cupola ends below the carotid foramen. The pars cochlearis may be divided into two parts, the vestibular and the cochlear segments (Voit). The vestibular part is situated above and behind the cochlear segment. The cochlear part contains the cochlear duct and the vestibular part the saccule (Plates LXXXIII, LXXXIV).

On the lower part of the lateral surface of the cochlear part is the prominentia cochlearis inferior caused by the first turn of the cochlear duct. It is succeeded further up by a bigger prominence, the prominentia cochlearis superior which represents the second turning of the cochlear duct. In front and behind these prominences there are sulcii. The anterior sulcus, the sulcus septalis, corresponds with the septum spirale which runs in the interior of the cochlea. The globelike anterior cupola becomes narrower as it approaches the canalicular part of the auditory capsule with which it is continuous. The cochlear capsule is connected anteriorly to the alar process of the central stem by the alicochlear commissure. Medially the sphenocochlear commissure connects the cochlear capsule to the central stem at the antero-lateral corner and posteriorly, the basivestibular commissure anchors the cochlear capsule to the central stem. There is a narrow crescent shaped fissure, the basicochlear fenestra, between the medial border of the cochlear capsule and the central stem (Fig. XLVI, Plates LXXXIII, LXXXIV).

The vestibular segment is narrower than the cochlear segment and is characterised by the presence of a number of foramen. • The lateral surface bears the foramen ovale or vestibuli just below the junction of the canalicularis with the cochlear capsule. The foramen is situated half way between the anterior and posterior extremities, opposite the stylohyal cartilages and is oval in shape. The foot-plate of the stapes fits into this foramen. The foramen ovale is several times bigger than the footplate of the stapes and as development advances it gradually becomes smaller while at the same time the footplate increases in size, with the result that it fits exactly into the foramen in the adult (Fig. XLVI, Plates XLIX, L, LXXXVIII, LXXXVI).

There is a big foramen situated in the posterior region of the vestibular part facing the foramen jugulare, the foramen perilymphaticum. The stage under description shows the foramen perilymphaticum divided into two by means of a thin strip of cartilage, the processus recessus. During the early stages this foramen was observed as a big gap without the intermediate dividing strip of cartilage. The roof of the foramen is the base of the canalicular capsule which projects a little beyond the cochlear capsule jutting out in the form of a shelf. The medial and lateral margins of the foramen are formed by the corresponding medial and lateral walls of the cochlear capsule, whereas the floor is formed by the processus recessus. The processus recessus extends from the ventral margin of the perilymphatic foramen to the ventral surface of the projecting shelf of the canalicular capsule, thus enclosing a space, the recessus scalae tympani, which is the anterior portion of the original fissura metotica. The processus recessus gives rise to two apertures, one on the medial side, the aquaeductus cochleae which faces the cranial cavity through the most anterior part of the jugular foramen. The second foramen is on the lateral side, the fenestra rotunda, and faces backwards, downwards and outwards. Its medial border is the lateral margin of the processus recessus and the lateral border is formed by the lateral wall of the cochlear capsule (Plate LXXXVIII).

The medial wall of the vestibular segment bears a deep depression at the junction of the canalicular part. This depression is the internal auditory meatus in which are two foramina. The anterior foramen, the foramen acustica anterius or superius is the smaller of the two and is placed at a high level being separated from the lower one by means of a bridge of cartilage known as the crista falciformis. The lower foramen, the foramen acustica posterior or inferius is placed behind and below the crista falciformis. It is three or four times bigger than the anterior and is oval in shape. The acustic nerve passes through these foramina to the interior of the capsule (Fig. XLVII, Plates XLVIII, LXXXVIII).

At the anterior extremity of the vestibular segment of the cochlear capsule there is a thin bridge of cartilage extending from the antero-medial aspect of the canalicular capsule to the dorsal wall of the cochlear capsule, known as the prefacial commissure (or suprafacial). The prefacial commissure encloses a foramen, the primary facial foramen, through which the facial nerve passes out, emerging from the auditory capsule. Laterally a little distance behind the prefacial commissure is the tegmen tympani which extends from the antero-lateral wall of the canalicular capsule to the dorso-lateral wall of the cochlear capsule, thus enclosing a foramen, the secondary facial foramen. The tegmen tympani is also known as the lateral prefacial commissure. The facial nerve emerging from the auditory capsule passes first through the primary facial foramen and then through the secondary facial foramen enclosed by the lateral prefacial commissure. It then finds its way on the lateral surface of the auditory capsule through the sulcus facialis situated on the ventral surface of the crista parotica. Between the prefacial commissure (suprafacial) and the lateral prefacial commissure is an extracranial space, the cavum supracochleare, which is also known as the hiatus Fallopi through which the palatine branch of the facial nerve runs forward after emerging from the primary facial foramen (Fig. XLVII, Plates XLIX, LXXXV, LXXXVII).

The foramen jugulare is situated at the posterior extremity of the auditory capsule. It is roughly an oval shaped aperture surrounded by cartilage on all sides. Anteriorly the foramen is limited by the basivestibular commissure extending from the medial surface of the auditory capsule to the basal plate, posteriorly by the base of the occipital arch and laterally by the lamina alaris. The foramen jugulare gives exit to the glossopharyngeal, vagus and spinal accessory nerves and the internal jugular vein from the cranial cavity (Figs. XLVII, Plates XLVIII, XLIX, XC).

(c) The ala temporalis.

The ala temporalis chondrifies as a separate structure and becomes fused with the processus alaris. The stage under description shows the ala temporalis as a fully chondrified structure fused to the processus alaris without any evidence of suture at the junction. The processus alaris is the continuation of the alicochlear commissure which becomes fused to the antero-lateral corner of the central stem at the junction of the basal plate with the hypophyseal cartilage. The ala temporalis extends from the processus alaris outwards into the sphenoparietal fontanella partly dividing it into an anterior and posterior fissure. The cartilage is quite flat and no part of it is upstanding, as in some mammals where it has been termed the lamina ascendens. Specimens during the early stage of development show two processes, one anterior and another posterior extending outward from the ala temporalis with a notch between them. As the development advances these two processes join together enclosing the foramen ovale, through which the mandibular branch of the trigeminal nerve passes. The entire cartilage is in the form of a triangle with the foramen ovale in the centre and attached to the processus alaris by the medial angle. The anterior margin of the triangular cartilage carries a process near its junction with the processus alaris, the pterygoid process, directed downwards and forwards. The semilunar or the Gasserian ganglion is situated on the dorsal surface of the ala temporalis (Figs. XXXIV, XXXVII, Plates XLVIII, XLIX).

(d) The ala orbitalis.

The ala orbitalis is attached to the central stem behind the interorbito-nasal septum. This cartilage belongs to the appendages attached to the central stem but is also included among the lateral structures forming the chondrocranium. The ala orbitalis is a large triangular cartilage whose base forms the lateral wall of the cranial cavity. The cartilage is attached to the central stem by the apex which is divided into two roots. The anterior root, the preoptic, passes towards the interorbital septum anterior to the optic foramen and nerve and fuses with the septum. The posterior root, the metoptic root, joins the central stem behind the optic nerve. Between the preoptic and metoptic roots of the ala orbitalis the central stem bears a slight depression on its dorsal surface, known as the fossa chiasmatica which is limited behind by the tuberculum sellae. The foramen enclosed by the roots of the ala orbitalis is the optic foramen through which the optic nerve finds its exit from the cavum cranii. The dorsal surface of the ala orbitalis forms the floor of the cranial cavity, whereas the ventral surface forms the roof of the optic cavity (Plate LXXX).

The posterior border of the ala orbitalis forms the anterior boundary of the sphenoparietal fontanella and at the same time the anterior border of the superior orbital fissure (sphenoidal). This fissure comes into existence on account of the development of the ala temporalis into the large sphenoparietal fontanella and breaking it up into an anterior and a posterior fissure. Through the anterior fissure or the superior orbital fissure pass the oculomotor, trochlear and abducens nerves, as well as the branches of the trigeminal nerve. The anterior border of the cartilage forms the posterior boundary of the orbito-nasal fissure of the ethmoidal fissure which is large and oval shaped, situated between the ala orbitalis and the nasal capsule. The ethmoidal fissure is limited ventrally by the central stem and by the sphenethmoid commissure dorsally. The base of the ala orbitalis has two angles, of which the anterior is prolonged into a process which meets another similar process extending from the posterior dorso-lateral portion of the nasal capsule. The combined cartilage resulting from the union of these two processes is known as the sphenethmoid commissure, which encloses the orbito-nasal fissure. It is interesting to note that the sphenethmoid commissure is quite broad in other mammals, whereas in Ovis it is a thin plate of cartilage in the form of a rod arching over the orbito-nasal fissure. Fawcett observed the mode of development of the sphenethmoid commissure in Bos. During the early stages of development the anterior basal process of the ala orbitalis and the process from the posterior dorso-lateral portion of the nasal capsule remain separated from one another, but in later development, these two processes are joined together enclosing the orbito-nasal fissure. According to Dursy and Fawcett, in Ovis these two processes do not join even in the advanced stage of development. Present observations in a series of specimens that have been subjected to the whole mass stain show clearly that the two processes mentioned above have advanced fairly forwards close to each other and show a tendency to join. Perhaps in still later stages of development these two processes may join together without showing any evidence of fusion. The posterior basal angle of the ala orbitalis is continued backwards to join the parietal cartilage by means of the orbito-parietal commissure. The orbito-parietal commissure bridges over the spheno-parietal fontanella which is the largest opening in the side wall of the chondrocranium. This commissure is quite broad, thus recalling a primitive condition of its ancestors which had a solid side wall (Figs. LII, LIII, Plate LI).

The ala hypochiasmaticae are found in the early stages of development as small processes projecting towards the optic cavity from the metoptic roots of the ala orbitalis. As development advances these processes are found changing their direction and are finally seen as small projections directed backwards. It is interesting to note that while in some mammals the ala hypochiasmaticae develop independently and become attached to the preoptic roots of the ala orbitalis, in others they are attached to the metoptic roots. The present investigation reveals that the ala hypochiasmaticae in Ovis develop from the metoptic roots near their attachment to the central stem from the very beginning and do not develop as isolated cartilages (Fig. LII).

(e) The lateral nasal capsule.

Though the nasal capsule belongs to one of the structures appended to the central stem, it will conveniently be described under the lateral structures of the chondrocranium, especially in the section dealing with the nasal capsule.

III. Lateral Structures

The lateral structures of the chondrocranium are the ala orbitalis, the parietal plate, the supraoccipital cartilages and the commissures which bind these structures together.

The ala orbitalis has already been fully described and therefore requires no further treatment under this heading. The commissures will be taken up under a separate heading dealing with the various commissures binding the lateral structures together.

(a) The parietal plate.

The parietal cartilages form the greater part of the lateral wall of the cranial cavity in the otic region and are in the form of a thin, curved and quadrilateral plate standing vertically over the anterior region of the canalicular part of the auditory capsule. The caval and external surfaces of the cartilages are concave and convex respectively. There a number of fissures and foramina in them which gradually become reduced in size and closed completely as development of the chondrocranium advances. A big fissure is seen cutting the parietal cartilages into two portions in an antero-posterior direction. This fissure has been termed in the pig by Mead, the fissura laminae parietalis. A similar fissure has been observed by other authors, Spöndli (1846), Kölliker (1879) in the pig and by Decker (1883) in the sheep. The parietal cartilage unites posteriorly with the supraoccipitals of the same side. Anteriorly the cartilages give rise to a commissure, the parieto-capsular commissure, on their antero-ventral border which fuses with the middle of the anterior border of the canalicular capsule. The remainder of the anterior portions of the parietal cartilages joins the ala orbitalis through the medium of the orbito-parietal commissure. The dorsal margin of the plate forms the lateral border of the cranial cavity. The ventral margin partly forms the superior boundary of the occipito-capsularis superior or foramen jugulare spurium and partly the dorsal margin of the spheno-parietal fontanella. The specimen under description shows no evidence of fusion of the various cartilages with the parietal plate (Plates LIV, LV).

(b) The supraoccipital cartilage.

The supraoccipital cartilage forms the posterior portion of the side wall of the chondrocranium. It is a quadrilateral, curved plate standing vertically over the posterior portion of the canalicular part of the auditory capsule. Posteriorly the cartilage is related to the corresponding exoccipital cartilage to which it is joined. The exoccipitals chondrify earlier than the supraoccipitals and so in the early stages of development, the supraoccipitals are found in the form of procartilage with a distinct line of separation between the two cartilages. Anteriorly the supraoccipital cartilage joins the parietal plate. A number of small foramina are found in this cartilage which become reduced in size and finally closed as the development advances (Plate LIV).

The ventral border of the supraoccipital cartilage arches over the posterior border of the pars canalicularis of the auditory capsule and forms the superior boundary of the occipito-capsularis inferior fissure, which is limited anteriorly by the occipito-capsularis commissure and by the lamina alaris of the exoccipital cartilage posteriorly. The anterior limit of the cartilage may be roughly determined by drawing an imaginary line vertically through the anterior border of the occipito-capsularis inferior fissure. A similar line drawn through the posterior border of the fissure indicates the posterior boundary of the cartilage.

The striking feature that draws our attention in this cartilage is the presence of the tectum posterius fused to the dorsal border of the supraoccipital cartilage. This is the only region where the cranial cavity is roofed by a cartilage. The rest of the cranial cavity anterior to the tectum posterius is open dorsally and is closed only by the development of the membrane bone. The tectum posterius is a curved plate of cartilage arching over the posterior region of the cranial cavity, connecting the dorsal borders of the supraoccipital cartilages. Its posterior margin forms the vault of the foramen magnum. In this specimen the anterior portions of the cartilages have fused in the mid dorsal line. The posterior portions are still separated by means of a narrow fissure, thus showing that the tectum posterius is of double origin and became fused together in the mid dorsal line as the development advances (Fig. XLIII).

(c) The nasal capsule.

The nasal capsule of Ovis is of considerable length and height. The whole capsule is bent at an obtuse angle to the rest of the chondrocranium. It consists of a central stem or the nasal septum and two lateral appendages. The nasal septum is the direct continuation of the central stem of the chondrocranium and has already been described at length along with the central stem of the chondrocranium and so needs no further consideration. The capsule is attached to the rest of the chondrocranium by means of the central stem in the middle line and by the spheno-ethmoidal commissure at the dorso-lateral angle with the corresponding anterior basal angle of the ala orbitalis. The capsule is bent in such a way that a portion of it comes to lie under the brain and accordingly it may be divided into a subcerebral and a precerebral part (Fig. XXXIX).

The nasal capsule is knitted into its final shape and size by three different cartilages, each having separate centres of chondrification, which develop at different intervals. The three cartilages are the parietotectal, the paranasal and the lamina orbito-nasalis. The parietotectal cartilage is the first to develop from the dorsal edge of the nasal septum. It forms the roof and anterior side wall of the nasal capsule. The roof of the capsule is also known as the tectum nasi and the side wall, the paries nasi. The next cartilage to develop is the lamina orbitonasalis which forms the posterior cupola and floor of the nasal capsule. The paranasal cartilage develops next forming the intermediate portion of the side wall and overlapping the posterior margin of the parietotectal cartilage and the anterior margin of the lamina orbito-nasalis. This results in the projection of the posterior margin of the parietotectal cartilage into the nasal cavity as the crista semicircularis and that of the anterior margin of the lamina orbito-nasalis as the first ethmoturbinal.

The subcerebral part - This part forms nearly a quarter of the entire length of the nasal capsule. It consists of a pair of cartilaginous plates known as the laminae cribrosae separated by means of the nasal septum. Each lamina cribrosa is in the form of a triangle with the base towards the nasal septum. The anterior arm of the triangle is short and forms the posterior boundary of the roof of the nasal capsule. This border extends from the root of the crista galli, the backward extension of the nasal septum, to the postero-lateral angle, where it joins the spheno-ethmoidal commissure. The postero-lateral arm of the triangle is longer than the anterior and forms the anterior boundary of the orbito-nasal fissure. There are four ridges emerging from the postero-lateral wall, the crista intercribrosa which runs obliquely from behind forward and inwards across the lamina cribrosa, dividing it into a number of compartments. Two of these intercribrosa are of a considerable size and may be regarded as primary ridges when compared with the smaller ridges, the secondary crista intercribrosa situated on either side of them. There is a pair of the secondary type of ridges jutting into the foramina cribrosa from the anterior wall of the lamina cribrosa. These ridges divide the cribrous plate into a number of compartments which are further subdivided into a number of smaller foramina through which the olfactory nerves pass. The laminae cribrosae are pushed from their primitive vertical position into an almost horizontal plane by the greater expansion of the brain in mammals in general. The position of the cribriform plates of Ovis prove no exception to this. These are in the form of two concave plates broad above and narrow below directed forwards and upwards facing the cranial cavity (Fig. LVI, Plate LXXIX).

The precerebral part - The roof of the precerebral part of the nasal capsule is formed by the parietotectal cartilage which descends gradually forwards from the lamina cribrosa. The parietotectal cartilage is attached to the dorsal border of the nasal septum in such a way that a longitudinal groove runs all along the length of the nasal capsule between the two cartilages. This groove has been termed the sulcus supraseptalis. The parietotectal cartilage joins the paranasal posteriorly and its junction is marked dorsally by the presence of a small foramen, the epiphanial foramen, through which the nasal branch of the profundus nerve passes. Below this foramen, the junction of the two cartilages is marked by a sulcus which runs vertically downwards and forwards known as the sulcus lateralis anterior. This sulcus on the lateral surface of the nasal capsule coincides in the interior with the attachment of the crista semicircularis. The anterior border of the tectum nasi forms the boundary of the fenestra narina (Fig. LVII, Plate LXXIII).

<u>The lateral wall of the nasal capsule or paries nasi</u>.

For the convenience of description the lateral surface of the nasal capsule may be divided into three parts namely, the pars anterior, pars intermedia and pars posterior. These parts are formed by the parietotectal, paranasal and the lamina orbito-nasal cartilages respectively.

The pars posterior - This portion is formed as mentioned above by the lamina orbito-nasalis and is the smallest of the three segments. It is separated from the pars intermedia by means of a sulcus, the sulcus lateralis posterior which runs vertically downwards and backwards behind the bulging portion of the paranasalis till it reaches the ventral margin of the cartilage. The posterior sulcus coincides in the interior with the line of attachment of the first ethmoturbinal. The lateral surface of the cartilage gives an appearance of a quadrilateral plate turned inside at the postero-ventral end forming the posterior cupola. The posterior margin of the quadrilateral plate forms the anterior margin of the orbito-nasal fissure and is confluent with the postero-lateral border of the lamina cribrosa. The anterior margin is attached to the paranasal cartilage at the sulcus lateralis posterior. The postero-dorsal angle is continued backwards as the spheno-ethmoidal commissure. Postero-ventrally the cartilage turns inside forming a considerable portion of the floor of the posterior cupola. It continues further forward on the floor to form the lamina transversalis posterior, which is separated from the ventral margin of the nasal septum by means of a fissure (Plate LVIII).

The pars intermedia - The paranasalis constitutes this part. The cartilage bulges out externally in the form of a globe beyond the general contour of the lateral surface of the nasal capsule. It is marked off anteriorly from the the parietotectal cartilage by means of the sulcus lateralis anterior and posteriorly from the lamina orbito-nasalis by the sulcus lateralis posterior. Close examination of the lateral surface of this cartilage reveals besides the main ventral bulging two more smaller prominences, one at the postero-dorsal angle and another at the anterior margin. These prominences have been termed, the prominentia superior or frontalis, the prominentia inferior or maxillaris and the prominentia anterior, according to the situation and the membrane bones which overlap these prominences in the later stages of development. These prominences correspond with the hollows in the interior of the capsule, thus the prominentia superior or frontalis corresponds with the recessus frontalis, the prominentia inferior or maxillaris with the recessus maxillaris. The prominentia anterior which projects on the anterior border of the cartilage corresponds with the hollow at the junction of the recessus frontalis and recessus maxillaris on the internal aspect of the lateral wall of the nasal capsule. These prominences are separated from one another externally by shallow depressions or sulcii.

The paranasalis is narrow above and broad below giving roughly the appearance of a triangle. The ventral margin rolls inwards and forms the floor of the recessus maxillaris. It is continuous posteriorly with the lamina transversalis posterior and with the ventral margin of the parietotectal cartilage anteriorly. The epiphanial foramen is situated at the dorsal third of the junction of the parietotectal and the paranasal cartilages as mentioned (Fig. LVII, Plate LVIII).

The pars anterior - This part is formed by the parietotectal cartilage. It is the longest segment of the nasal capsule extending from the paranasal cartilage to the fenestra narina. The cartilage is quite broad and deep posteriorly and becomes narrow and less deep as it is traced forwards. The posterior border of the cartilage is overlapped by the paranasal cartilage and projects into the nasal cavity as the crista semicircularis. The place of junction between the two cartilages is marked externally by the sulcus lateralis anterior which coincides with the crista semicircularis in the interior. The superior border of the parietotectal cartilage fuses with the dorsal border of the nasal septum forming the roof of the nasal capsule. Between the parietotectal cartilages there runs a groove all along the dorsal border of the nasal septum, the sulcus supraseptalis, to which reference has already been made. The posterior part of the parietotectal cartilage bears inferiorly, a longitudinal groove beyond which the cartilage extends downwards bulging slightly externally below the level of the maxillo-turbinal. This portion of the cartilage may be termed the lamina infraconchalis from its position. The nasolacrimal duct runs in the groove and hence it may be called the nasolacrimal sulcus (Plate LIX).

The inferior border of the parietotectal cartilage is continuous behind with the ventral margin of the paranasal cartilage and extends in front forwards and upwards in an arched fashion being closely followed and covered by the nasolacrimal duct. Above the nasolacrimal sulcus, the cartilage shows a longitudinal projection, which corresponds to the hollow in the interior. The posterior part of the parietotectal cartilage is deep while the anterior part is shallow and carries a series of small foramina in an antero-posterior direction near its dorsal border. These foramina gradually become smaller and finally disappear as the chondrocranium advances in age. The inferior border of the parietotectal cartilage is joined anteriorly to the lamina transversalis anterior which connects it to the nasal septum. There is no fissure between the nasal septum and the lamina transversalis anterior and a complete ring of cartilage is formed, known as the zona annularis (Fig. LX, Plate LXXVI).

If the ventral border of the parietotectal cartilage is followed from behind forwards it is found to join the posterior border of the lamina transversalis anterior at the incisura transversalis posterior. It then continues forward over the lamina, jutting out in the form of a shelf till it reaches the anterior border of the lamina, the incisura transversalis anterior. In front of this incisura the ventral border continues once again as a free border for a little distance. At the place where the ventral border just out in the form of a shelf there is a longitudinal sulcus in which the nasolacrimal duct is lodged. This duct first follows the ventral border of the parietotectal cartilage posteriorly and then continues forward through the sulcus in the lamina transversalis anterior to reach the incisura transversalis anterior, where it bends forwards and inwards to reach the mucous membrane of the nose. The anterior free border of the parietotectal cartilage ascends upwards to end in a notch formed by the downwardly directed process, the processus alaris superior. This process is formed at the junction of the anterior and the ventral borders of the paries nasi. The anterior openings of the nasal capsule, the fenestra narinae, are directed forwards being separated from each other by the nasal septum, which extends for some distance in front of the fenestra with its height gradually decreasing as it passes forwards. There is no cupola anterior in Ovis as the fenestra narina opens directly in front. The absence of the fenestra superior, found in Lepus is also worth noting (Fig. LX, Plates LXXVI, LXXV).

The lamina transversalis anterior - This connects the nasal septum directly with the lateral wall of the nasal capsule. There is no fissure between the lamina and the nasal septum as is found in Lepus (Voit), hence a complete ring of cartilage, the zona annularis, is formed in this region. The cartilage is triangular in shape with the base attached to the nasal septum and the apex to the under margin of the lateral wall of the nasal capsule. The posterior border of the cartilage is short and upright forming with the ventral border of the parietotectal cartilage, the incisura transversalis posterior. The anterior border is long and slanting and forms with the parietotectal cartilage, the incisura transversalis anterior, where the nasolacrimal duct bends inwards to reach the mucous membrane of the nose (Fig. LXI, Plates LXXVI, LXIII, LXIV).

At the junction of the apex of the lamina transversalis anterior cartilage with the under surface of the lateral wall of the nasal capsule is a sulcus through which the nasolacrimal duct passes forwards. Corresponding to this sulcus in the interior of the capsule, the ventral margin of the paries nasi projects inwards forming the atrioturbinal which is continuous behind with the maxilloturbinal (Plate LXXVI).

The processus alaris superior - This process is of considerable length and is formed at the junction of the anterior and the ventral borders of the paries nasi. It first extends downwards and backwards and then forwards. It encloses at the root, posteriorly, a well defined deep rounded notch to which no name has been assigned (Fig. LX, Plate LXXIII).

The fenestra narina anterior - This is the anterior external opening of the nasal capsule. It is bound dorsally and laterally by the anterior border of the parietotectal cartilage, which joins the nasal septum medially. There is no anterior cupolar cartilage in Ovis as the fenestra narina opens directly forwards. The fenestra is filled with a solid epithelial plug in the early stages of development as shown in Plate LXVII.

The floor of the nasal capsule - This is also known as the solum nasi. The nasal capsule is closed on all sides except the anterior and the ventral sides. The anterior opening, the fenestra narina, has already been described. One of the ventral vacuities is quite big and is known as the fenestra basalis or choanalis situated behind the lamina transversalis anterior. The fenestra basalis is surrounded by cartilages on all sides, namely, anteriorly by the lamina transversalis anterior, posteriorly by the lamina transversalis posterior, medially by the paraseptal cartilage and laterally by the ventral margin of the paries nasi. The aperture of the fenestra basalis is narrowed by the presence of the cartilago-ectochoanalis which is also termed the palatine cartilage or the processus posterior lateralis extending backwards from the lamina transversalis anterior. The second vacuity is the septo-paraseptal fissure, which intervenes between the paraseptal cartilage and the lamina transversalis posterior laterally, and the infero-lateral border of the septum nasi medially. It should be noted that the lamina orbito-nasalis is separated from the nasal septum in the region of the lamina transversalis posterior by means of the septo-paraseptal fissure (Fig. LXII).

The paraseptal cartilage - The paraseptal cartilage is a paired structure extending beside the ventral edge of the nasal septum. It encloses the Jacobson's organ in its anterior portion. The stage under description shows the paraseptal cartilage extending from the lamina transversalis anterior backwards, still being separated from the lamina transversalis posterior. There is a narrow longitudinal fissure between the ventral margin of the nasal septum medially and the paraseptal cartilage and the lamina transversalis posterior, laterally. This fissure is known as the septo-paraseptal fissure and the paraseptal cartilage is attached above it to the nasal septum by a band of connective tissue (Fig. LXII, Plates LXXVII, LXXIV).

Describing the paraseptal cartilage from behind forwards, it is in the form of a solid cartilaginous rod posteriorly. It continues forward for a little distance as a cartilaginous plate (medial lamella) by the side of the ventral margin of the nasal septum, which soon assumes an L-shaped form. The two arms of the L-shaped cartilage become equal in length as traced forward with the result it may be mentioned that the paraseptal cartilage in this region is bilaminar with a medial and a lateral lamella. Soon these two lamellae meet together to form a tube in which Jacobson's organ is lodged. The paraseptal cartilage is continued further anterior to the lamina transversalis anterior as the cartilago ductus nasopalatini with a ventral longitudinal opening. The position of the paraseptal cartilages in relation to the nasal septum varies from the anterior to the posterior regions. Most anteriorly they are placed on either side of the ventral crest of the nasal septum with a wide space between them. Soon this space narrows down and the paraseptal cartilages of the two sides come close together, ventral to the nasal septum. Further behind the space increases once again and the two paraseptal cartilages gradually shift from their ventral position to that of a lateral one, running alongside the nasal septum (Fig. LXII, Plates LXIII, LXIV, LXXIII, LXXIV, LXXVII).

The lamina transversalis posterior - This forms the greater part of the floor of the posterior region of the nasal capsule. Posteriorly it is fused with the posterior cupola of the lamina orbito-nasalis. Laterally it is continuous with the ventral margin of the paranasalis. Medially it is directed towards the nasal septum but is separated from it by means of the septo-paraseptal fissure mentioned above. The lamina transversalis posterior forms the posterior boundary of the fenestra basalis (Fig. LXII, Plate LXXIX).

<u>The medial aspect of the lateral wall of the nasal capsule.</u>

The medial aspect like the lateral is divisible into the same number of parts namely the posterior, the intermediate and the anterior.

The pars posterior or pars ethmoidalis - This is characterised by the presence of a number of ethmoturbinals projecting into the nasal cavity from the lateral wall and the lamina cribrosa. There are three big or major ethmoturbinals and between them three small or minor turbinals. These are otherwise known as the primary and the secondary endo and ectoturbinals, depending upon their size (Figs. LXV, LXVI, Plate LXIX).

The pars posterior is bounded laterally and posteriorly by the lamina orbito-nasalis and the posterior cupola, dorsally by the slanting lamina cribrosa and ventrally by the floor of the lamina transversalis posterior. The anterior boundary is marked by the projection of the anterior border of the lamina orbito-nasalis into the nasal cavity which coincides with the formation of the first ethmoturbinal. The first ethmoturbinal coincides on the external surface of the nasal capsule with the sulcus lateralis posterior.

The ethmoturbinals - The stage under consideration shows three primary ethmoturbinals named from before backwards, the first, second and third according to the priority of their development. The first ethmoturbinal is the biggest of the three and the third is the smallest. The first ethmoturbinal is not only distinguished by its size but also by the presence of three roots. The dorsal root projects from the lamina cribrosa, whereas the ventral and the anterior roots are from the medial aspect of the lateral wall of the nasal capsule. All these three roots are continuous with one another. The first ethmoturbinal has two lamellae, the dorsal and the ventral. The dorsal lamella is the larger of the two and is triangular in shape. It projects anteriorly over the anterior root, thus hiding from view, from the medial aspect, a considerable portion of the pars intermedia. This ethmoturbinal forms the posterior boundary of the pars intermedia. The ventral lamella is shorter than the dorsal and is attached only by the ventral root in common with the dorsal. Between these two lamellae on the lateral side the secondary ethmoturbinal, which is hidden from view by these, could be seen in the hollow.

The second primary ethmoturbinal is smaller than the first and is separated from it by a narrow meatus and, like the first ethmoturbinal, has two lamellae. It extends from the lamina cribrosa above to a point behind the ventral root of the first ethmoturbinal. The anterior lamella is short and broad, whereas the posterior is long and narrow. The posterior lamella is connected at either end by the anterior and the posterior roots, while the anterior lamella springs from the ventral root in common with the posterior lamella. On the lateral side, the secondary ethmoturbinal is lodged in the hollow between these two lamellae.

The third primary ethmoturbinal is the smallest of the three being situated at the ventral part of the pars posterior. It extends from the lamina cribrosa forwards to end on the medial aspect of the lateral wall of the nasal capsule. The third secondary ethmoturbinal is situated in the hollow between the second and third ethmoturbinals. The ventral roots of all three primary ethmoturbinals are united together and project forwards hiding the pars intermedia from view. There is a narrow meatus between the second and third primary ethmoturbinals (Figs. LXV, LXVI, Plates, LXIX, LXXIX).

The pars intermedia - This part appears on the external surface like a dome and is deeply concave with its convexity anterior on the medial aspect of the lateral wall of the nasal capsule. It is limited posteriorly by the first ethmoturbinal and anteriorly by the crista semicircularis. The crista semicircularis is the backward projection of the posterior border of the parietotectal cartilage into the nasal cavity and coincides on the external surface of the nasal capsule with the sulcus lateralis anterior which has already been dealt with. The crista semicircularis forms the common boundary between the pars intermedia and the pars anterior on the medial aspect of the lateral wall. It commences just below the epiphanial foramen and runs vertically downwards and forwards where it dies away into an insignificant ridge. There is no free part projecting downwards, the processus uncinatus, found in the rabbit (Voit).

A considerable portion of the pars intermedia is hidden from view on the medial aspect by the forward extension of the anterior root of the first ethmoturbinal. This root divides the deeply concave recess of the pars intermedia into a superior or frontalis recessus and an inferior or recessus maxillaris. In front of the anterior root of the first ethmoturbinal, these two recesses are continuous by means of a narrow recess, the recessus anterior. These recesses seen on the medial aspect of the pars intermedia give rise to the corresponding projections on the lateral aspect of the paranasal cartilage, which have been referred to previously in the description of the lateral aspect. The ventral margin rolls inwards forming the backward extension of the maxillo-turbinal (Plates LXIX, LXXVIII, Fig. LXVI).

The recessus frontalis or superior - This is situated above the superior and the anterior roots of the first ethmoturbinal and is hidden from view by the dorsal lamella of the first ethmoturbinal. It is further subdivided into three secondary recesses by two frontoturbinals which run parallel to each other in an antero-posterior direction. The dorsal of the two is more prominent and extends from the cribriform plate to a point just behind the anterior root of the first ethmoturbinal (Fig. LXVI).

The recessus anterior - This is situated in front of the anterior root of the first ethmoturbinal and forms the narrow junction between the recessus frontalis and the recessus maxillaris. It is limited anteriorly by the crista semicircularis and posteriorly by the anterior root of the first ethmoturbinal. This recess is indicated on the lateral surface of the nasal capsule by the anterior prominence of the paranasal cartilage.

The recessus maxillaris - This lies below the recessus frontalis being connected to it anteriorly by the recessus anterior. The recessus maxillaris is the biggest of the recesses present. Its superior boundary is formed by the inferior lamella of the first ethmoturbinal and it is deeply concave giving rise to the dome shaped bulging on the external surface. Anterior to the recessus maxillaris and inferior to the crista semicircularis is the recessus glandularis in which the lateral nasal glands are lodged. The recessus glandularis is not clearly perceptible as it is the smallest recess without any boundary line and is occupied by the lobes of the gland (Fig. LXVI).

The pars anterior - This part is like a scroll attached to the nasal septum, triangular in shape with the apex anteriorly. The base is quite broad and deeply concave, being limited by the crista semicircularis. The anterior margin forms the lateral boundary of the fenestra narina. The pars anterior is divided in its length into two unequal portions by the nasoturbinal which stretches longitudinally from the anterior fourth to the cribriform plate. The portion dorsal to the nasoturbinal is the narrower of the two and is roofed by the parietotectal cartilage. The ventral part is broad and the maxillo-turbinal forms the floor (Fig. LXVI).

The atrioturbinal - This is the inrolling of the ventral border of the parietotectal cartilage at the anterior end. It is continued posteriorly with the maxillo-turbinal without any interruption. There is a notch between the atrioturbinal and the maxillo-turbinal filled with fibrous tissue and in this respect the atrioturbinal varies from that of Lepus. It coincides in the region of the lamina transversalis anterior externally with a longitudinal sulcus through which the nasolacrimal duct passes (Fig. LXVI, Plates LXXV, LXIX).

The maxillo-turbinal - This is the inrolling of the ventral border of the pars anterior, posterior to the atrio-turbinal and is continuous with the atrioturbinal anteriorly. Tracing it from before backwards it is found to be narrow to begin with, being overlapped by the nasolacrimal duct on the external side. It continues backwards becoming quite broad and running along the upper edge of the lamina infra-conchalis which stands vertically. The maxillo-turbinal reaches its greatest thickness near its posterior third. Then it once again becomes narrow gradually sloping backwards and downwards. Posteriorly it is continuous with the inrolled ventral margin of the pars intermedia of the nasal capsule. At the junction of the pars intermedia with the pars anterior the recessus glandularis is lodged and has already been described above. In front of the atrioturbinal the dorsal and the ventral divisions of the pars anterior are continuous (Fig. LXVI, Plates LXXVII, LXIX, LXXVIII).

IV. The Lateral Commissures.

Generally the commissures are given the names of the structures between which they establish connection. Enumerating these commissures from before backwards they are

(a)/

(a) The spheno-ethmoidal commissure.

The spheno-ethmoidal commissure connects the posterior dorso-lateral process of the nasal capsule with the anterior basal angle of the ala orbitalis. It arches over the orbitonasal fissure in the form of a rod, this feature being characteristic of Ovis. In the specimen under description the commissure is still incomplete (Plate LIV).

(b) The spheno-parietal commissure.

The spheno-parietal commissure extends from the posterior basal angle of the ala orbitalis to the anterior border of the parietal plate. It is quite broad and upstanding completing the dorsal boundary of the spheno-parietal fontanella, which is the largest fissure found in the lateral wall of the developing chondrocranium (Plate LIV).

(c) The parieto-capsular commissure.

The parieto-capsular commissure is the ventro-lateral extension of the parietal plate which comes in contact with the anterior border of the pars canalicularis of the auditory capsule. It limits the anterior extent of the occipito-capsularis superior fissure. This commissure has been called by different names in the various species depending upon the mode of its development. For instance in Lepus (de Beer) the ala orbitalis establishes connection first with the auditory capsule and then with the parietal plate and so has been called the orbito-capsular commissure (Plate LI).

(d) The occipito-capsular commissure.

The occipito-capsular commissure establishes connection between the antero-lateral angle of the supra-occipital and the dorsal border of the auditory capsule. It divides the otherwise large crescent-shaped occipito-capsularis fissure into two, the superior and the inferior (Fig. XLVII, Plate XLVIII).

(e) The lamina alaris.

The lamina alaris of the exoccipital cartilage meets the posterior border of the canalicular capsule a little lateral to the border, thus enclosing a narrow space between the, the recessus supra-alaris. This commissure limits the dorsal extent of the jugular foramen (Plate L).

The Splanchnocranium or the Visceral Arch Skeleton.

The first visceral arch:

The Meckel's cartilage is a cylindrical rod extending from the auditory capsule forward as far as the anterior tip of the nasal septum. Although in cross section the cartilage is cylindrical in shape the diameter varies at different levels. At the anterior extremity the Meckel's cartilage unites with its fellow of the opposite to form a symphysis. Posteriorly the cartilage passes directly into the cartilaginous malleus without any line of demarkation. Its course may be described from behind forwards as follows. From the auditory capsule the cartilage sweeps round and extends forward, after a constriction, in an almost parallel line. Then, at the level of the prominentia maxillaris, it is followed by a constriction and an expansion and continues further forward towards its fellow of the opposite side to form the symphysis mentioned above (Plates LXVII, LXXXI).

Posteriorly the Meckel's cartilage bends downwards and forwards to form the cartilaginous malleus. The malleus articulates within the incus at the convex side of the bend. It then continues further downwards and forwards gradually tapering to a point, thus forming the manubrium mallei. Two prominences are recognisable on the body of the malleus (Fig. LXVIII).

The incus has a body and two arms, a short arm, the crus breve and a long arm, the crus longum. It is attached to the under surface of the crista parotica at the fossa incudis by the crus breve. The crus longum extends downwards and backwards gradually diminishing in diameter. At the posterior end there is a slight expansion after a constriction which will be replaced by the os lenticularis in the later development of the skull. The body articulates with the bent portion of the Meckel's cartilage, the future malleus. The incus and the malleus are in a plane external to the stapes which is situated a little inside (Fig. LXVIII).

<u>The second visceral arch</u>:

The stapes extends from the lenticular expansion of the incus to the foramen ovale. It is in the form of a stirrup with two arms meeting at an acute angle. At the base of the triangle is the footplate which fits into the foramen ovale. The foramen ovale is nearly three or four times larger than the footplate but as development advances the footplate of the stapes increases in size while there is a corresponding diminution of the foramen ovale, with the result that the footplate fits exactly into the foramen as seen in the adult skull (Fig. LXVIII).

<u>The hyoid cartilages:</u>

The specimen under description shows all the cartilages of the hyoid apparatus in a fully chondrified condition. The Reichert's cartilage was noticed during the early stages of development to be formed by two pieces of cartilage, the laterohyal and the stylohyal, which have now combined together without showing any line of demarkation. The Reichert's cartilage is also known as the tympanohyal. Proximally it fuses with the crista parotica of the canalicular part of the auditory capsule. In the early stages of development the line of separation between the crista parotica and the Reichert's cartilage was clearly indicated by a transverse line stained faintly, but this specimen shows no such line, thus indicating a complete fusion between the two parts. The proximal portion of the cartilage is slightly more expanded than the portion below it. The cartilage follows a sinuous course, downwards and forwards on the lateral side of the cochlear part of the auditory capsule, till it reaches roughly the level of the ala temporalis ventrally. The Reichert's cartilage is in the form of a strap and shows a backwardly directed process in the middle of its length wherein there is a slight expansion of the cartilage on either side. Inferiorly it is attached to a short rod, the ceratohyal, the future middle cornu of the hyoid apparatus. At the other end, the ceratohyal is joined to a stumpy cartilage, the hypohyal, directed downwards and backwards. This forms the short cornu of the hyoid apparatus (Fig. LXX, Plate LXXI).

The basihyal is in the form of a rod placed transversely joining the hypohyal of one side with its fellow of the opposite side. The basihyal articulates at its antero-lateral corner with the hypohyal or the small cornu and at the postero-lateral corner with the thyrohyal. The thyrohyal cartilages are in the form of cylindrical rods directed backwards and upwards from the postero-lateral corner of the basihyal, to the superior process of the corresponding ala of the thyroid cartilage. The ala of the thyroid cartilage is fused to the fellow of the opposite side in the mid ventral line and is open widely dorsally. The ala increases in depth from before backwards. Anteriorly there is a small gap between the two alae. The dorsal border of the ala is prolonged both anteriorly and posteriorly and the anterior prolongation, the superior process, is directed forwards and upwards to meet the thyrohyal cartilage. The posterior prolongation is short and meets the cricoid cartilage (Fig. LXXII).

The cricoid cartilage is in the form of a signet ring with the broad end dorsally placed. Anteriorly it is connected to the posterior process of the thyroid cartilage. The arytenoid cartilages are seen as paired nodules placed anterior to the cricoid cartilage over the dorsal border of the thyroid cartilage (Fig. LXXII).

Study of Certain Aspects of the Osteocranium of Ovis

A search of the literature reveals that no systematic study of the development of the osteocranium of Ovis has ever been attempted except by very few authors like Claus (1911) and Lacoste (1927) who studied only the development of the preinterparietal and supraoccipitals respectively. In the present investigation an endeavour is made to trace the development of various bony constituents of the skull in Ovis up to the stage studied in the development of the chondrocranium. Specimens of various sizes and ages have been subjected to mass staining by the Alizarin method to trace the ossified bones. The result obtained by this method has been confirmed by further study of the serial sections of embryos prepared for the investigation of the chondrocranium described in the previous chapter. Bones have been classified into membrane bones and cartilage bones according to the mode of origin. Eight stages of development have been selected for this study and their description is as follows.

Stage I.
13 mm. H.H.

Membrane bones:

The dentary - This is by far the largest membrane bone in this stage. As a matter of fact the dentary is the first membrane bone to develop and therefore attains a considerable size. It extends along the Meckel's cartilage in an antero-posterior direction in the form of double lamellae, one on either side of the cartilage. The external lamella has attained a considerable length while the medial lamella is only a small spicule projecting backwards from the anterior region. The anterior extremity is ill-defined and starts a little distance away from the symphysis of the Meckel's cartilage. The posterior extremity which is quite broad stops short of the cartilage. The dorsal and the ventral borders are well defined.

The frontal - This is a thin strip arching over the dorsal border of the orbit. Very few osteogenic fibres are seen distributed in this stage.

The maxilla - This is second in size when compared to the dentary. The main portion of the body is seen with the future infraorbital foramen in the form of a gap. Posteriorly it carries a thin blunt process ventral to the orbit, the zygomatic process of the maxilla.

The malar - This is a thin strip curving along the ventral surface of the orbit.

The squamosal - This bone appears in the temporal region dorsal to the auditory capsule like a club with the broad end posteriorly.

Cartilage bones:

There is yet no sign of cartilage bone formation.

Stage II

(Plates LXXIV, XCII)

G 33 - 14 mm. H.H.

Membrane bones:

The dentary - There is not much variation in the size and length of the external lamella, whereas the medial lamella has extended further backwards reaching almost a third of the length of the mandible.

The frontal - A slight increase in size is observed.

The maxilla - The feature which draws attention in this region is the development of the palatine plate of the maxilla which juts out medially like a shelf. No change in the size and shape of the body is seen.

The malar - There is no change from that of the previous stage.

The squamosal - A slight increase in length anteriorly is perceptible. The bone shows a tendency to become flat posteriorly.

The palatine - This bone appears for the first time in this stage. It is a thin streak situated at the posterior extremity of the palatine plate of the maxilla.

Stage III.

(Plate XCIII)

G 4 - 16 mm. H.H.

This stage shows a distinct advancement over the previous stage as can be seen by the extension of the osseous tissue in the various parts.

Membrane bones:

The dentary - This bone has not only extended in length but also in height. The medial lamella has covered nearly three quarters of the length of the mandible. The coronoid process is seen extending backwards but there is yet no indication of the formation of the condyle. The mental foramen is like a longitudinal slit situated in the anterior region of the bone.

The frontal - This shows considerable extension of ossification. The orbital plate comes into existence like a short strap descending downwards from the dorsal orbital rim. Besides the main body of the frontal bone there appears another centre of ossification away from the main body and lying close to the mid dorsal line.

The parietal - This bone appears for the first time as a triangular piece posterior to the frontal. A wide gap intervenes between the centres on each side.

The maxilla - This bone has increased in size. The infraorbital foramen which was like a notch extending from the superior border of the bone has closed and only the foramen for the passage of the infraorbital artery and nerve is left. There is a marked improvement in the palatine plate of the maxilla. It has extended backwards and is in confluence with the palatine bone. The zygomatic process has extended slightly in length beneath the malar like a blunt cone.

The palatine - Both the horizontal and the vertical plates are visible.

The premaxilla - The premaxilla appears for the first time like a thin streak anterior to the maxilla representing the nasal process.

The malar - This bone has developed further but still remains unattached to the surrounding bones. It forms the ventral margin of the orbital cavity.

The lachrymal - The lachrymal appears for the first time at the antero-internal angle of the orbit, like a small cone with the apex towards the malar.

The squamosal - The zygomatic process stretches freely forwards and the posterior portion has increased in size.

Cartilage bones:

The hyoid - Reichert's cartilage has ossified at the posterior extremity near the auditory capsule.

This may be considered as one of the important stages since many new centres of ossification have appeared, the parietal, the premaxilla, the lachrymal and the hyoid.

Stage IV

(Plate XCIV)

G 34 - 17 mm. H.H.

Membrane bones:

The dentary - There is not much change in the size and shape of this bone. The medial lamella is in the same state of development as in Stage III. The only feature which draws attention is the growth of the coronoid process which has become a big hook-like structure extending backwards. The anterior and the posterior borders are still ill-defined. The mental foramen maintains its slit-like form. Anteriorly the dentary of both sides is separated by a wide gap which means that the anterior portion of the Meckel's cartilage is still uncovered and the mandibular symphysis is yet to be formed.

The frontal - The two centres of ossification mentioned in the previous stage have coalesced resulting in a broad platelike structure covering the major portion of the future cranium and extending from the posterior part of the nasal capsule to the parietal bone. There is not much change in the orbital plate.

The parietal - The area of ossification has increased slightly but a wide space still exists between the two bones.

The maxilla - No perceptible change has taken place in this bone except for the slight increase in length of the zygomatic process.

The premaxilla - The nasal process has increased in size. The body and the palatine process have not yet appeared.

The palatine - This bone appears to be better ossified than in the previous stage since it has taken a deeper stain.

The pterygoid - The pterygoid has appeared for the first time and only the hamulus is seen ossified.

The malar - This bone has increased slightly in size.

The lachrymal - There has been a slight increase in size.

The squamosal - There has been an increase in the size of the body which has become like a curved plate.

Cartilage bones:

The exoccipital - Only the condyle portion has ossified.

The hyoid - The part of the Reichert's cartilage described in the previous stage develops further into a well defined, deeply stained structure.

The new centres of ossification in this stage are the exoccipital and the hamulus of the pterygoid.

Stage V

(Plates LXXVII, XCV)

G 30 - 19 mm. H.H.

Membrane bones:

The dentary - The condyles are beginning to form.

The frontal - The area of ossification has extended further and a distinct margin between the frontal and the orbital plate of the frontal forming the dorsal margin of the orbital rim is observed. The posterior border is still separated from the parietal.

The parietal - The postero-external angle of this bone extends to meet the squamosal plate.

The maxilla - The zygomatic process stretches further backwards and lies ventral to the malar. The alveolar border is observed as a wide gap between the body of the maxilla and the palatine process.

The premaxilla - The premaxilla is unchanged from the previous stage.

The palatine - Both the horizontal and the vertical plates are better ossified with clear outlines.

The pterygoid - A rapid advancement over the previous stage is evident from the ossification of the main body of the bone as well as the hamulus process.

The malar - Posteriorly two processes are seen of which the lower one is longer extending below the zygomatic process of the squamosal while the upper smaller process lies above it.

The lachrymal - In the previous stages only the facial part of this bone was recognisable but now the orbital part can be observed. It is pierced by a foramen, through which the nasolachrymal duct passes.

The squamosal - There is a slight increase in the size of the body.

The nasal - This bone appears over the roof of the nasal capsule like a small island.

The tympanic - The tympanic is like a thin strip bent in the form of a half crescent in the ventral portion of the auditory capsule.

The vomer - The vomer is represented by a thin streak of bone dorsal to the palatine plate of the maxilla along the medial line.

Cartilage bones:

The exoccipital - The extent of ossification of the condyle is the same as in the previous stage.

The basioccipital - The basioccipital arises as a median piece in the posterior portion of the basal plate and has the appearance of an oval plate.

The basipostsphenoid - The basipostsphenoid arises in the hypophyseal cartilage. It appears like a short oval rod placed transversely to the longitudinal axis of the skull.

The alisphenoid (wing of the postsphenoid) - This is formed by the ossification of the alar process and the ala temporalis. It is shaped like a fork with a handle.

The orbito-sphenoid (wing of the presphenoid) - The orbito-sphenoid arises in the ala orbitalis lateral to the optic nerve. The ossification extends from the preoptic root of the ala orbitalis like a crescent. The body of the presphenoid has not yet been ossified.

The hyoid - There is no change over the previous stage.

The malleus - The ossification centre appears in the neck of the Meckel's cartilage like a small triangle.

It is interesting to note that several new centres of ossification have appeared in the chondrocranium in a single stage. The new centres in this stage are the mandibular condyle, the tympanic, the vomer, the basioccipital, the basipostsphenoid, the alisphenoid, the orbito-sphenoid, the nasal and the malleus.

Stage VI

(Plates LXXIX, XCVI)

G 3 - 22 mm. H.H.

Membrane bones:

The dentary - The length of this bone has increased according to the size of the skull. The medial lamella has reached the full length of its growth. The condyle is still in formation. The alveolar border identifies itself as a raised ridge on the dorsal border of the horizontal part of the mandible.

The frontal - No further improvement over the previous stage is noticeable.

The parietal - The ossification has spread over a greater area resulting in the narrowing of the gap between the bones of the opposite side.

The nasal - There is a slight increase in the size of the bone.

The maxilla - The maxilla is unchanged except for a slight increase in size.

The premaxilla - The body and the palatine process have appeared in this stage. The nasal process has stretched backwards a little further and is in contact with the anterior border of the body of the maxilla.

The palatine -

The pterygoid - These bones show no improvement from

The malar - the previous stage.

The lachrymal -

The squamosal - The body has expanded further and the zygomatic process has a twisted appearance.

The tympanic - There is a marked increase in the length of the bone and consequently its appearance is semi-circular.

The vomer - The ossification has extended in an antero-posterior direction resulting in the formation of a long scroll-like bone.

Cartilage bones:

The exoccipital - The condyle emerges out more prominently than in the previous stage and its root is surrounded by a greater area of ossification.

The basioccipital - A slight increase in size is noticeable.

The basipostsphenoid - This has increased in length and consequently connects the alisphenoid on either side.

The alisphenoid - The ossification has spread medially and hence the bone has met the basipostsphenoid which at the same time has extended laterally as mentioned above. There is no change in the size and shape of the fork-like wing of the postsphenoid.

The orbito-sphenoid - Both the preoptic and the metoptic roots of the ala orbitalis are ossified giving the final shape to the optic foramen which looks complete except for the medial boundary, the body of the presphenoid which is not yet ossified.

The hyoid - There is no change in the area of ossification.

The malleus - There is a slight increase in the area of ossification and the bone looks more defined.

Stage VII

(Plates XLVII, XCVIII)

G 35 - 25 mm. H.H.

Since there is not much change in many of the bones only the new centres of ossification are mentioned in this stage.

Membrane bones:

The interparietal - This bone appears as an irregular piece behind the parietal at the postero-internal angle on each side. It is important to note that the interparietal has two centres of ossification, one on either side of the medial line.

Cartilage bones:

The occipital arch - The occipital arch appears in the region of the tectum posterius as a small triangular piece of bone placed mid dorsally with the base facing the interparietals and the apex towards the foramen magnum.

The alisphenoid (wing of the postsphenoid) - The fork-like bony structure observed in the previous stage has ossified further completing the foramen, the foramen ovale, through which the mandibular branch of the trigeminal passes.

Stage VIII

(Plate XCIX)

G 29 - 31 mm. H.H.

Membrane bones:

The dentary - The mandibular symphysis is not yet formed and therefore the dentary of one side is separated from its fellow of the opposite side by a narrow space. The bone does not reach so far forward as the end of the Meckel's cartilage. The various constituent parts of each half may now be recognised, the ramus, the angle, the coronoid process and the condyle.

The frontal - This bone has reached its full size and the orbital plate extends up to the orbito-sphenoid bone.

The nasal - This bone has increased in size and appears as an oval body with the base towards the anterior border of the frontal bone.

The parietal - The area of ossification has spread further and consequently the space between the two bones has narrowed down.

The interparietal - This bone is unchanged from the previous stage.

The maxilla - There is a general increase in size and the anterior border is in contact with the nasal process of the premaxilla. The zygomatic process is now in contact with the ventral surface of the zygomatic arch. The facial tuberosity is recognisable as a laterally protruding mass with the infraorbital foramen at its anterior end.

The premaxilla - The only noteworthy change in this stage is the backward extension of the nasal process which comes in contact with the maxilla.

The palatine - This bone is similar to that of the previous stage.

The pterygoid - The body shows a slight increase in size.

The malar - This completes the zygomatic arch which is firmer in this stage since the union with the lachrymal bone anteriorly and the zygomatic process of the squamosal posteriorly is complete.

<u>The lachrymal</u> - There is a slight general increase in size.

<u>The squamosal</u> - The zygomatic process presents a twisted appearance and shows ventrally the formation of the condyle for the articulation of the mandible.

<u>The tympanic</u> - The tympanic is the same as in the previous stage.

<u>The vomer</u> - There is no change from the previous stage.

<u>Cartilage bones:</u>

<u>The exoccipital</u> - There is no change from the previous stage.

<u>The basioccipital</u> - The anterior portion has extended further changing the shape of the bone from its original oval shape to that of a flask.

<u>The occipital arch</u> - There is a definite increase in the area of ossification. It appears like two oval bodies joined together in the middle with a cleft behind.

<u>The basipostsphenoid</u> - The breadth of this bone has increased giving the appearance of a flat band running transversely.

<u>The alisphenoid</u> -
<u>The orbito-sphenoid</u> - No change is visible from
<u>The hyoid</u> - the previous stage.

<u>The malleus</u> - The area of ossification has increased and the bone looks like a small triangle at the neck of

the Meckel's cartilage.

The important changes in this stage are the formation of the angle and the condyle of the mandible and the extension of the orbital plate of the frontal.

Summary

The results of the investigation in the study of the chondrocranium of Ovis may be summarised as follows -

1) The parachordals or the basal body are of a paired origin, having centres of chondrification one on either side of the notochord.

2) The parachordals are quite broad to begin with, but become narrow in the middle being compressed between the cochlear parts of the auditory capsules.

3) The parachordals are separated from the cochlear part of the auditory capsule by means of a narrow crescent shaped fissure, the basicochlear fissure.

4) The course of the notochord is not transbasal.

5) A pair of hypoglossal foramina are found on either side of the notochord.

6) The hypophyseal cartilage is of a paired origin with centres of chondrification, one on either side of the hypophyseal foramen.

7) The dorsum sellae is present in the form of a vertical plate at the anterior end of the basal plate.

8) The hypophyseal fossa is limited anteriorly by the tuberculum sellae.

9) There is a short orbitonasal septum between the preoptic root of the ala orbitalis and the lamina orbito-nasalis.

10) The nasal septum projects backwards dorsally in the form of a beak, the crista galli process, beyond the

level of the cribriform plate.

11) There is no fenestra septalis in Ovis.

12) The nasal septum extends anteriorly a short distance beyond the fenestra narina, thus separating the narina of each side from its opposite fellow.

13) The cribriform plate assumes a horizontal position from its primitive vertical position.

14) There is a sulcus supraseptalis dorsally extending the entire length of the nasal septum in the form of a groove.

15) The foramen magnum is formed by the tectum posterius and not by the tectum synoticum.

16) A well developed paracondylar process is present.

17) The fissura lamina parietalis is present between the parietal and the supraoccipital cartilages.

18) The parietal cartilage establishes connection first with the anterior border of the canalicular part of the auditory capsule, thus giving rise to the parieto-capsular commissure, instead of the orbito-capsular commissure.

19) The orbito-parietal commissure is quite broad and upstanding, forming the side wall of the chondrocranium.

20) The ala orbitalis is joined to the central stem by means of two roots, the preoptic and the metoptic.

21) The ala hypochiasmatica develops from the metoptic root of the ala orbitalis near its junction with the central stem. It does not chondrify as an isolated structure.

22) The sphenethmoid commissure is in the form of a thin rod extending from the postero-dorsal angle of the nasal capsule arching over the orbitonasal fissure. It is not a broad structure as in other mammals.

23) The nasal capsule develops from three sources, namely the parietotectal, the paranasal and the lamina orbitonasalis cartilages.

24) There is no fenestra superior nasi.

25) The foramen perilymphaticum is divided into two, the foramen rotundum and the foramen aquaeductus by the processus recessus.

26) The tegmen tympani is well developed.

27) The suprafacial commissure is single.

28) The foramen acusticum is divided by the crista falciformis into a superior and an inferior foramen.

29) The alicochlear commissure develops from the cochlear part of the auditory capsule and extends forwards to join the processus alaris.

30) The posterior basicapsular commissure is of the basivestibular commissure type.

31) The sphenocochlear commissure extends from the cochlear part of the auditory capsule to the antero-lateral corner of the parachordals.

32) The ala temporalis chondrifies independently and becomes joined to the processus alaris.

33) The pterygoid process extends from the anterior border of the ala temporalis forwards and downwards.

34) The anterior and the posterior paraseptal cartilages are not only separated from each other but also from the nasal septum by means of the septo-paraseptal fissure.

35) There is a complete ring of cartilage, the zona annularis, formed by the union of the lamina transversalis anterior with the nasal septum.

36) The fenestra narinae open directly forward and there is no cupola anterior.

37) The palatine cartilages are directed backwards from the lamina transversalis anterior.

38) The cartilago ductus palatini extends forwards anterior to the lamina transversalis anterior, on the lateral side of the nasal septum.

39) The Reichert's cartilage is formed by two strips of cartilage, the laterohyal and the stylohyal.

40) The proximal extremity of the Reichert's cartilage is fused to the crista parotica of the canalicular part of the auditory capsule.

41) The mastoid process is not yet formed.

42) The Meckel's cartilage is not of uniform thickness.

43) The chondrocranium is open dorsally except in the posterior region where it is roofed by the tectum posterius.

44) Though the cartilages of the chondrocranium appear earlier in the development of an embryo their ossification is preceded by the membrane bone.

45) The first membrane bone to appear is the dentary.

46) The frontal and the parietal bones develop more rapidly than any other bones of the cranium to roof the brain effectively.

47) The interparietals have two centres of ossification and therefore there are two separate pieces of bone instead of a single piece in the middle.

48) The basipresphenoid and the auditory capsule do not ossify till late in the development.

49) The malleus is the first to ossify amongst the auditory ossicles.

50) With the exception of a portion of the Reichert's cartilage no other part of the hyoid arch is ossified till late in the development.

Discussion

The extensive description of the primordial cranium of Lepus given by Voit (1909) has been adopted as a standard throughout this investigation of the chondrocranium of Ovis. The formation of the different cartilages has been followed from the very beginning through the various stages of development of the embryo and observations have been made on the following cartilages.

The parachordals:

Earlier authors established that the paired origin of the parachordals, one on each side of the notochord is found in almost all the vertebrates, but Noordenbos (1905) observed a single unpaired parachordal in Talpa, Lepus, Bos and Sus. Terry (1917), in his description of the primordial cranium of the cat observed that the parachordals arise in the form of paired strips of cartilage, one on each side of the notochord. There is a pair of parachordal cartilages in Ovis, as in other mammals, one pair on each side of the notochord, at first in the form of triangular plates. These parachordals become fused with the occipital arches at their lateral extremity in such a way that it is difficult to demarkate the line of fusion. Fawcett (1918A) observed in his description of the skull of Erinaceus that the occipital arches may be demarkated from the posterior region of the parachordals by drawing an imaginary line in an antero-posterior direction through the hypoglossal foramen situated at the junction of these two cartilages. The parachordals in Ovis are also situated median to the hypoglossal foramen and extend forwards along the notochord.

The basal plate forms an obtuse angle to the anterior region of the central stem. It is moderately wide in the posterior region, and narrows down in the middle, due to the medial extension of the cochlear part of the auditory capsule, from which it is separated by the narrow crescent shaped basicochlear fissure. The anterior extremity becomes slightly broad once again and ends in a well marked dorsum sellae. The basal plate compares favourably with Sus scrofa (Mead 1909, Lehedkin 1918, Noordenbos 1905, Decker 1883, Parker 1874), Felis Domestica (Decker 1883, Wincza 1896, Kernan 1915, Terry 1917) and Canis familiaris (Olmstead 1911). In Bos taurus (Decker 1883) and Equus caballus (Noordenbos 1905) the basal plate is very wide and fuses completely with the cochlear capsule, and the basi-cochlear fissure is absent.

The notochord:

The notochord is seen running in an antero-posterior direction in the basal plate during the early stages of development but in the advanced stages it disappears completely. The course of the notochord differs in different species. It has been described as transbasal, when it traverses dorsally to the hindmost part of the basal plate, ventrally to the middle portion and becomes embedded in the anterior portion, Lepus (Voit 1909 and de Beer 1930), Homo (Fawcett 1910, Levi 1900, 1909, Von Noorden 1887).

The notochord in Ovis lies wholly within the basal plate and hence may be described as belonging to the intrabasal type. It varies slightly from that of Capra but agrees to a greater extent with that of Bos. It runs in Ovis through the hindmost part of the basal plate, then becomes embedded in the middle part and continues forward in the anterior part inclined towards the pharynx. The notochord in Capra runs through the hindmost part of the basal plate, then dorsally in the middle part and continues embedded in the anterior part, whereas in Bos it runs dorsally to the hindmost part of the basal plate and is embedded in the middle and anterior parts. Mead (1909) observed in the primordial chondrocranium of Sus scrofa that the notochord is connected to the dorsal wall of the pharynx in two places. In Ovis the anterior end of the notochord is seen connected to the dorsal wall of the pharynx.

The hypoglossal foramen:

The 20 mm. C.R.L. embryo shows the hypoglossal foramina in the form of notches situated on the anterior border at the junction of the postero-lateral part of the parachordals with the occipital arches. In the 26 mm. embryo these notches are converted into foramina and thus a single large foramen is seen on each side of the notochord. As development advances the foramen on each side tends to divide into two by a constriction in the middle. Finally in the 28 mm. C.R.L. embryo a pair of foramina lie on each side of the notochord, a small anterior foramen and a large posterior foramen arranged in an antero-posterior direction.

It is interesting to note that the number of hypoglossal foramina not only varies in a single genus but also in the species. In an embryo of Semnopithecus pruinosus Fischer observed two hypoglossal foramina on the left side and three on the right side. Semnopithecus maurus shows a single foramen on each side. Voit (1909) found a pair of hypoglossal foramina on each side in Lepus. Usually one pair of hypoglossal foramina is seen in all placental mammals e.g. Felis (Terry 1917), Sus (Mead 1909), Dog (Olmstead 1911). The single foramen mentioned above becomes double in the older embryos of sheep.

The polar cartilages:

Generally it is considered that the floor of the chondrocranium is made up of two portions namely, the parachordals or the basal plate posteriorly, and the trabeculae anteriorly which continue as the nasal septum. It has been established by a number of authors, Van Wijhe (1904, 1922), Veit (1911) and Sonies (1907) that the trabeculae consist of an anterior trabecular portion (nasal septum), and a posterior polar element. In the lower vertebrates, the polar cartilages are situated behind the trabeculae lateral to the internal carotid arteries and are connected across by a median plate of cartilage, known as the hypophyseal plate. The internal carotid arteries enter the cranial cavity on either side of the hypophyseal cartilage.

In placental mammals, the polar cartilages are represented by the alicochlear commissure which stretches from the cochlear part of the auditory capsule to the processus alaris, thus forming the external boundary of the foramen through which arterial branches pass. The alicochlear commissure generally extends from the processus alaris backwards to the cochlear capsule. Noordenbos observed that the case was similar in Talpa and called it the synchondrosis sphenocochlearis lateralis. De Beer's investigation of the chondrocranium of Lepus reveals that the alicochlear commissure starts from the anterior end of the cochlear part of the auditory capsule and extends forwards to meet the processus alaris. This was also found to be the case in Ovis. The processus alaris chondrifies earlier than the alicochlear commissure and is already attached to the ala temporalis. The alicochlear commissure in Ovis is delayed in its development and is seen in its early stages as a small process projecting forward from the cochlear capsule, while the ala temporalis and the processus alaris are fully chondrified. De Beer observes that the alicochlear commissure in mammals bears the processus alaris as in the lower vertebrates though the latter may chondrify earlier than the former which is also true of Ovis.

<u>The hypophyseal cartilage</u>:

The hypophyseal cartilage has been called the polar plates by Noordenbos and the pars tuberalis of the central stem by Fawcett. Fawcett divided the central stem into three parts, namely, the pars chordalis (basal plate), the pars trabecularis in the middle and the pars interorbito-nasalis in front. The hypophyseal cartilage belongs to the trabecularis of Fawcett's description. Since the chondrocranium has been traced from the very beginning in this investigation the hypophyseal cartilages are observed to begin as paired patches in the 18 mm. C.R.L. embryo, one on each side of the hypophyseal foramen. The junction between this cartilage, the parachordals and trabecula is seen in an up to 21 mm. C.R.L. embryo as faintly stained lines running transversely. It is only during the later stage of development that the hypophyseal cartilage becomes fused with the above mentioned parts without any line of demarkation. It is noteworthy that the fusion of the hypophyseal cartilage with the parachordals takes place median to the branches from the internal maxillary artery.

The hypophyseal cartilage in Lepus starts in the form of a ring surrounding the hypophyseal foramen (de Beer 1930) and in Felis (Terry 1917) it is like a bar behind the hypophyseal stalk. This cartilage is seen in other forms as a paired patch situated on each side of the hypophyseal foramen, namely Homo (Fawcett 1918) and Echidna (Gaupp 1908). The present investigation of Ovis reveals that the hypophyseal cartilage has a paired origin, the right and the left, one on each side of the hypophyseal foramen. A number of authors, Fawcett 1918 (Homo, 'pars trabecularis'), Terry 1917 (Felis, 'hypophyseal cartilage'), Noordenbos 1905 (Talpa, 'polar plates'), Fawcett 1921 (Tatusia, 'pars trabecularis'), Gaupp 1908 (Echidna, 'trabecula'), have established that the hypophyseal cartilage chondrifies separately and becomes fused to the basal plate posteriorly and the interorbito-nasal septum anteriorly.

During the early stages of development the arteries are seen entering the cranial cavity through notches on either side of the hypophyseal cartilage. Later these notches are converted into foramina by the development of the alicochlear commissure. It may be said that the mode of development of the hypophyseal cartilage in Ovis is in keeping with the observations in other mammals, namely it is a separate cartilaginous element between the parachordals and the interorbito-nasal septum.

The ala hypochiasmatica:

An ala hypochiasmatica projects from the metoptic root of the ala orbitalis, its mode of development and attachment varying in different forms. In Lepus (de Beer 1930) it starts as an isolated patch of cartilage near the preoptic root of the ala orbitalis and is attached to the central stem as well as the preoptic root enclosing a small foramen. In man it is attached both to the preoptic and metoptic roots but in the majority of mammals it is attached to the metoptic root only, namely, Erinaceus europaeus (Fawcett 1918), Microtus amphibius (Fawcett 1917), Felis domestica (Terry 1917), Canis familiaris (Olmstead 1911), Sus scrofa (Mead 1909), and Otomys tropicalis (Eloff 1951).

The earliest embryo to show the ala hypochiasmatica in Ovis is the 20 mm. stage. It is seen attached to the metoptic root near its fusion with the central stem and develops as a small ventral projection of the metoptic root which becomes prominent as development advances.

The interorbital septum:

The part of the central stem posterior to the nasal capsule and anterior to the preoptic root of the ala orbitalis has been termed the interorbital septum. The presence of a keel-like and well developed interorbital septum is a primitive character found in reptiles and birds. It is associated with the large size of the eyeballs which press the interorbital septum into a thin vertical plate between the eyes and push the brain case to the more posterior region of the skull. In mammals the vertical appearance is obscured by the greater development of the brain which extends forwards and compresses the central stem downwards and at the same time by the formation of the secondary palate. The presence of a well developed interorbital septum in mammals indicates a primitive character exhibited by the reptilian ancestors.

On account of the backward extension of the nasal capsule especially the posterior part, the lamina orbitonasalis, a portion of the original interorbital septum has been usurped into the nasal cavity as part of the nasal septum resulting in some mammals having a feebly developed interorbital septum, e.g. Canis (Olmstead 1911), Bos (Fawcett 1918A), Otomys (Eloff 1951) and Ovis. In Primates Homo (Macklin 1921), Semnopithecus (Fischer 1903), Macacus

(Fischer 1903), Chrysothrix (Henckel 1928A) and in Rodents, Lepus (Voit 1909), and Microtus (Fawcett 1917), there is a well developed interorbital septum. This may be connected with the fact that in Primates the nasal capsule is reduced in size with the result that a greater length of the nasal septum is left behind the nasal capsule as the interorbital septum, while in Rodents the nasal capsule has not encroached so much on the interorbital septum and so a well developed septum of the reptilian ancestor is observed.

The degree of extension of the nasal capsule is indicated by the length and fusion of the paraseptal cartilage with the lamina transversalis anterior and posterior. Rodents show the paraseptal cartilage still attached to both the anterior and posterior lamina transversalis, thus showing that the backward extension of the nasal capsule does not break off the union between the paraseptal cartilage and the lamina transversalis posterior. Hence a well developed interorbital septum is observed in Rodents. In other mammals like Ovis the paraseptal cartilage is seen stopping short of the lamina transversalis posterior, thus indicating a backward extension of the nasal capsule which has incorporated a portion of the interorbital septum into the nasal cavity as the nasal septum, and so a feebly developed interorbital septum is present.

The nasal capsule:

The nasal capsule of a 25 mm. H.H. embryo is nearly one third of the total length of the chondrocranium but as development advances the nasal capsule reaches nearly half the length of the total chondrocranium. This explains the lengthening of the face in the adult skull. The whole nasal capsule is bent at an obtuse angle to the rest of the cranium in the early stages but comes to lie in a more or less horizontal plane along with the base of the cranium in the later stages of development. In accordance with the development of the nasal capsule in mammals generally there are three independent cartilages constituting the capsule, with separate centres of chondrification. Of these, the first cartilage to develop is the parietotectal cartilage from the dorsal edge of the nasal septum. It forms the roof and anterior side wall of the nasal capsule and is attached to the dorsal border of the nasal septum in such a way that a longitudinal groove, the sulcus supra-septalis, runs all along the length of the nasal capsule. In this respect the sulcus supraseptalis of Ovis resembles those of Homo, Lepus (de Beer 1930), Bos (Strum 1937) and Sus (Mead 1909).

The lamina orbito-nasalis develops next forming the posterior cupola and posterior floor of the nasal capsule. The intermediate portion is formed by the paranasal cartilage overlapping the posterior margin of the parietotectal cartilage which projects into the nasal cavity as the crista semicircularis. The junction between these two cartilages is indicated on the exterior by the sulcus lateralis anterior. The remnant of the original gap between the two cartilages before the fusion is represented by the epiphanial foramen situated dorsal to the above sulcus through which the nasal branch of the trigeminal nerve passes. The posterior margin of the paranasal cartilage overlaps the anterior margin of the lamina orbito-nasalis which projects into the nasal cavity as the first ethmoturbinal.

There is no fenestra septi in Ovis. Sus (Mead 1909, and Parker 1874), shows a thin portion in the anterior part of the nasal septum, a short distance from the nasal opening. In Talpa (Fischer) there is an opening at this place filled with connective tissue. The absorption of the cartilage in the nasal septum a short distance from the nasal opening is considered as an adaptation in connection with the flexibility of the nose (Spurgat 1896). Erinaceus and Canis are also characterised with a similar gap in the nasal septum. The posterior dorsal extremity of the nasal septum projects backwards in the form of a blunt cone known as the crista galli.

Another interesting feature in the nasal capsule of Ovis is the absence of the cupola anterior since the narinal opening is directed forwards and also the absence of the fenestra superior nasi on the lateral wall. The lamina transversalis anterior joins the nasal septum and so a complete ring of cartilage, the zona annularis, is formed as in Microtus (Fawcett 1917), Sorex (de Beer 1929), Erethizon (Struthers 1927) and Canis (Olmstead 1911). The lamina transversalis anterior on the lateral side bears a sulcus through which the naso-lacrimal duct passes. The lamina orbito-nasalis curves inwards to form the posterior cupola and the lamina transversalis posterior. The lamina transversalis posterior does not fuse with the septum and is separated from it by a narrow fissure, the septo-paraseptal fissure as in Lepus (de Beer and Woodger 1930), Microtus (Fawcett 1917), Sorex (de Beer 1929) and Felis (Terry 1917).

The paraseptal cartilages extend from the lamina transversalis anterior backwards for two-thirds of the length of the nasal capsule, but do not fuse with the lamina transversalis posterior. This gap explains the fact that the nasal capsule has extended backwards resulting in the original union of the lamina transversalis posterior with the paraseptal cartilages being broken up. The same argument stands to justify the feeble development of the interorbital septum since the nasal capsule has encroached backwards and incorporated a part of the original long interorbital septum into the nasal cavity. Posteriorly the paraseptal cartilages are in the form of solid cartilaginous rods. They continue forward for a little distance as cartilaginous plates (medial lamellae), by the side of the ventral margin of the nasal septum, and soon take the form of a tube in which Jacobson's organ is lodged. The paraseptal cartilages continue further, anterior to the lamina transversalis anterior, as the cartilago ductus nasopalatini with a ventral longitudinal opening.

Broom, in his series of articles on the nasal capsule of different mammals, traced the part of the paraseptal cartilage containing the Jacobson's organ. He classified the mammals into two groups, namely, 'Archaeorhinata' containing an outer bar of Jacobson's cartilage and 'Caenorhinata' including Artiodactyla, Perissodactyla, Carnivora and other groups in which the outer bar is absent and at the same time the capsule is extended forwards from the lamina transversalis anterior as the cartilago ductus nasopalatini. It has been confirmed that Ovis belongs to the Caenorhinata group by possessing a distinct cartilago ductus nasopalatini, as do Equus (Spurgat 1896) and Bos (Michalkovics 1899). At the same time the outer bar is also present in the form of a short rod attached to the lower limb of the 'C' shaped paraseptal cartilage. Hence it may be concluded that though a distinction has been drawn between the two groups it is perhaps bridged over by forms possessing the characters of both groups. A distinct outer bar has been recognised in Sus, Equus and Sorex though they belong to the Caenorhinata group.

The palatine cartilage which represents the primitive cartilaginous nasal floor is found in Ovis and also in many other mammals, Echidna (Parker 1894, Gaupp 1908), Sorex (de Beer), Tupaja (Broom 1915), Lepus (Broom 1900, Voit 1909), Felis (Broom 1900, Terry 1917).

The sphenethmoid commissure:

The development of the sphenethmoid commissure is in accordance with Decker's (1883) observations in the sheep.

It is seen as a small process, in the early stages of development, extending backwards from the postero-dorsal angle of the nasal capsule. The fully formed chondrocranium shows this commissure as a cone-like structure arching over the orbitonasal fissure, with the base attached to the nasal capsule and the apex towards the anterior angle of the ala orbitalis. It stops short of the ala orbitalis. Thus at no stage of development of the chondrocranium has the sphenethmoid commissure been observed to unite with the ala orbitalis.

This commissure in other mammals is observed as a well developed vertical flat band arching over the orbitonasal fissure and connecting the anterior angle of the ala orbitalis with the nasal capsule, e.g. Lepus (de Beer 1930), Felis (Terry 1917), Sus (Mead 1909), Canis (Olmstead 1911), Sorex (de Beer 1929), Microtus (Fawcett 1917), Erinaceus (Fawcett 1918), Poicilophoca (Fawcett 1918) and Otomys (Eloff 1951).

<u>The parietal plate</u>:

A fissure, the fissura laminae parietalis, was observed in the posterior part of the parietal plate. This is in accordance with the findings of Spondli (1846) and Kölliker (1879) in Sus and Decker (1883) in the sheep.

The orbito-parietal commissure which is fairly broad is homologous with the reptilian taenia marginalis. Prior to its attachment with the ala orbitalis, it gives off the parieto-capsular commissure which joins the anterior border of the canalicular part of the auditory capsule. Generally this commissure bears the names of the structures between which it establishes connection, but since the various cartilages develop at different intervals the connection is made in the various forms by different cartilages. In Lepus (de Beer 1930) the orbital cartilage establishes connection first with the auditory capsule and then with the parietal cartilage. Hence the commissure is known as the orbito-capsular commissure, whereas in Ovis, as in Talpa and Felis, the parietal cartilage establishes connection first with the auditory capsule and later with the ala orbitalis.

The ala temporalis:

The ala temporalis cartilage has been observed in the chondrocranium of Ovis to be a strap-like structure continuous with the basal plate through the processus alaris and extending outwards at the junction of the hypophyseal cartilage with the basal plate. At no stage in its development has it been observed to develop as an isolated independent structure. The junction of the ala temporalis with the processus alaris could be easily made out by the faint margin of procartilaginous tissue which had taken a fainter stain than the surrounding area. This line of junction indicates that the ala temporalis is a separate structure from that of the basal plate and that it becomes attached to the antero-lateral extremity of the basal plate by the processus alaris and is not a continuous process.

This view is contrary to the statement of Wincza who had observed the ala temporalis in sheep as a continuous structure extending from the basal plate. In earlier stages of Homo, Felis and Canis, Wincza (1896) found the ascending part of the ala temporalis chondrifying as a separate piece of cartilage and later uniting with the processus alaris.

The specimens of Ovis that were examined did not show the ala temporalis as an isolated structure separated from the basal plate, but from the structure of the tissue at the junction of the ala temporalis with the processus alaris it is suggested that the ala temporalis must have started as a separate cartilage and then joined the processus alaris.

The ala temporalis of Ovis agrees fully in shape with that of Sorex. In Sorex (de Beer 1929) the ala temporalis is a plate-like structure in continuity with the basal plate and the lamina ascendens, which is a flat cartilage with a notch at the outer extremity for the passage of one of the branches of the trigeminal nerve. Hence the term lamina ascendens is not fitting in the case of Ovis.

In Lepus (de Beer and Woodger 1930) two laminae are attached to the ala temporalis, of which one is the lamina ascendens, directed forward and upwards, standing up between the profundus and the maxillary branches of the trigeminal nerve on one side and the mandibular branch on the other side. According to the upstanding position of the lamina the term lamina ascendens is quite appropriate in Lepus.

Terry (1917) observed the ala temporalis in Felis extending, from the processus alaris opposite the sella turcica, outwards beneath the semilunar ganglion and the junction between the processus alaris and the ala temporalis. The ala temporalis bears the lamina ascendens and a small medial pterygoid process. The lamina ascendens is a triangular cartilaginous plate extending laterally and dorsally towards the commissure orbito-parietalis but remaining separated from it. Thus the term lamina ascendens is quite fitting in the case of the cat.

The processus alaris in the pig is like a cartilaginous rod (Mead 1909), as in Homo and Echidna. It is attached to the central stem near the anterior half of the floor of the hypophyseal fossa. The ala temporalis is attached to the processus alaris. Neither the foramen nor the notch is present in the ala temporalis for the passage of blood vessels and nerves.

This is a point of interest in the pig, when compared with that of Ovis, the ala temporalis of which bears a notch in the earlier stages and a complete foramen in the fully developed chondrocranium. The presence of a foramen for the passage of one of the branches of the trigeminal nerve has been mentioned in other forms as well, like Sorex (de Beer 1929), Lepus (de Beer 1930) and Felis (Terry 1917). The term lamina ascendens in the pig is quite proper in view of its upstanding position.

Another point worthy of noting in the chondrocranium of Ovis is that the processus alaris develops earlier than the alicochlear commissure. The alicochlear commissure which represents the polar cartilages bears the processus alaris, though the latter chondrifies earlier than the former (de Beer 1930). At no stage in this investigation is the processus alaris observed to chondrify as an independent cartilage. It is seen from the beginning attached to the basal plate along with the ala temporalis. The development of the alicochlear commissure is delayed and so it could be seen throughout the various stages developing as a process from the anterior region of the cochlear part of the auditory capsule. In the later stages it joins the processus alaris at its junction with the ala temporalis, thus forming the external boundary of the carotid foramen.

<u>The auditory capsule</u>:

The auditory capsule makes its first appearance in the 15 mm. C.R.L. embryo as an independent isolated piece of cartilage in the form of an island in front of the occipital arch. The first part of the capsule to appear is the canalicular part in the procartilaginous stage. It is like an equilateral triangle with the angles rounded off. After the canalicular part has reached a certain stage of chondrification the cochlear part develops on the ventromedial side of it. The development of the auditory capsule has been discussed in detail by de Beer in his paper on the chondrocranium of the shrew. The cochlea is absent in the skulls of fish and Amphibia and consequently its presence in a fully developed condition in mammals is considered as an extension of the original auditory capsule of the Amphibian ancestor.

Gaupp (1900) considers these capsules as being derived from the basal plate and puts forth a number of points in favour of his argument, one of these being that the basal plate is narrow between the cochlear parts. Observations made by Noordenbos (1905) and de Burlet (1916) are in agreement with those of de Beer in that the cochlear part is an extension of the original auditory capsule and is not derived from the basal plate. The two parts, namely the basal plate and the auditory capsule, have been observed to chondrify individually being separated by a fissure, the basicochlear fissure. It is only in the later stages of development that the auditory capsule becomes anchored to the central stem by a number of commissures with the fissure existing in between. The presence of the basicochlear fissure is a characteristic feature in most of the mammalian chondrocranii and has been found in this investigation of Ovis and in the following mammals; Talpa (Fischer 1901), Miniopterus (Fawcett 1919), Lepus (Noordenbos 1905)(Voit 1909), Microtus (Fawcett 1917), Canis (Olmstead 1911), Felis (Terry 1917), Bos (Decker 1883)(Levi 1909) and Sus (Mead 1909).

The auditory capsules form part of the floor of the cranial cavity. The capsule is moored to the central stem of the chondrocranium by means of various commissures. The first commissure to establish connection with the basal plate is the basivestibular commissure extending from the cochlear part posterior to the basicochlear fissure. This commissure has been named differently depending upon its fusion with the basal plate in relation to the glossopharyngeal nerve, it has been termed the posterior basicapsular commissure. It incorporates a portion of the fissura metotica along with the glossopharyngeal nerve into the basicapsular fissure. On the other hand in some forms it joins the basal plate in front of the nerve and so it has been called the basivestibular commissure. The commissure in Ovis is of the basivestibular type.

The sphenocochlear commissure develops later than the basivestibular commissure when the chondrification of the auditory capsule is fairly advanced. This is also the case in the cat (Terry 1917) and Lepus (de Beer 1930), but in Erethizon (Struthers 1927) and Otomys (Eloff 1951) it is seen, even in the very early stages of development, extending from the blastematous basal plate to the blastema of the cochlear capsule. Hence Noordenbos' view that the cochlear capsule is phylogenetically an extension of the auditory capsule is correct. The third commissure to anchor the auditory capsule is the alicochlear commissure to which reference has already been made.

The canalicular part is also well anchored to the cranium by means of three commissures, the parieto-capsular, the occipito-capsular and the lamina alaris, thus giving this part a substantial fixation to the auditory capsule.

The shape of the auditory capsule depends upon the various parts contained therein. The prominence caused by the lateral semicircular canal deserves some attention. It juts over the cochlear capsule laterally in the form of a shelf known as the crista parotica lodging the sulcus facialis on its ventral side. The crista parotica extends along the entire length of the auditory capsule in an antero-posterior direction and anteriorly is extended forward as the tegmen tympani which is also known as the lateral prefacial commissure. It fuses with the lateral wall of the cochlear capsule enclosing the secondary facial foramen through which the facial nerve passes to the sulcus facialis.

Fischer (1901B) found in Talpa a broad connection between the vestibular and the cochlear parts perforated by an opening through which the palatine nerve passed. He concluded that the opening is the hiatus canalis facialis of the primitive facial canal, whereas Mead (1909) believes that the bridge of cartilage posterior to the hiatus is a secondary derivative, the forerunner of the later well developed osseous roof, the tegmen tympani found in mammals. The study of the chondrocranium of Ovis confirms Mead's observations in Sus. The tegmen tympani is seen at the beginning as a small hook-like structure projecting anteriorly downwards from the crista parotica. It joins the lateral wall of the cochlear capsule as stated above.

The space between the prefacial commissure and the tegmen tympani is the hiatus Fallopi through which the palatine nerve passes forwards, emerging from the primary facial foramen. The cavum supracochleare described by de Beer (1937) is present in Ovis. This cavity, according to de Beer, is a space lateral to the prefacial (suprafacial) commissure bounded externally by the tegmen tympani. The crista parotica gives rise to the mastoid process, which overlaps the styloid process posteriorly. Its appearance is considerably delayed in Ovis and even the largest chondrocranium studied in this investigation showed the mastoid process as only a small projection from the crista parotica, posterior to the styloid process.

It may be mentioned that the junction of the canalicular part with the cochlear part is characterised by the presence of a number of foramina. Enumerating them from the lateral side, the foramen ovale or vestibuli lies just below the junction of the two parts half way between the anterior and posterior extremities of the auditory capsule, opposite the stylohyal cartilage. It is oval in shape and the foot plate of the stapes fits into this foramen. In the early stages it is several times bigger than the foot plate. As development advances the foramen becomes gradually smaller while at the same time the foot plate increases in size with the result that it fits exactly into the foramen in the adult.

On the medial wall of the vestibular segment there is a deep depression, the internal auditory meatus in which two foramina are situated. The anterior foramen, the foramen acustica anterius or superius, is the smaller of the two and is placed at a higher level being separated from the lower one by means of the crista falciformis. The lower foramen, the foramen acustica posterior or inferius is placed behind and below the crista falciformis. The latter foramen is several times bigger than the former and is oval in shape. The acustic nerve passes through these foramina to the interior of the auditory capsule. In the early stages of development a small perforation, due to the deficiency of the cartilage, is observed in the dorsal region of the fossa subarcuata anterior interna, which disappears as development advances. Below the crus commune and behind the fossa subarcuata anterior interna is the foramen endolymphaticum. During the early stages this foramen is observed in the form of a longitudinal gap, running in a transverse direction which is reduced gradually as development advances and attains its final oval shape. The longitudinal gap of the foramen endolymphaticum has been observed in Sus, Talpa and Semnopithecus as well. It becomes oval in shape and is reduced in size in later development (Mead 1909). The endolymphatic duct of the membranous labyrinth passes out from the interior of the auditory capsule through this foramen.

There is a large foramen situated in the posterior region of the vestibular part facing the foramen jugulare, the foramen perilymphaticum. This foramen is a large single one in reptiles whereas in mammals it undergoes modification in the following manner. A process, the processus recessus, extends upwards from the hind end of the floor of the cochlear part of the auditory capsule and meets the base of the canalicular part which projects a little beyond the cochlear capsule as a shelf. This process was discovered by Fischer (1903) in Semnopithecus and in Lepus by Voit (1909). Terry (1917) observed the process ending freely in the cat. Thus in Ovis, as in other mammals, a space, the recessus scalae tympani, which is extracapsular in the reptilian skull is incorporated into the auditory capsule and the original single reptilian perilymphatic foramen is modified with two new apertures, laterally the fenestra rotunda and medially the aquaeductus cochleae, which are directed towards the cranial cavity through the most anterior part of the jugular foramen.

The boundaries of the foramen rotunda are laterally, the lateral border of the original foramen perilymphaticum and medially the lateral margin of the processus recessus. The floor is formed by the ventral margin of the cochlear capsule whereas the roof is formed by the posterior base of the canalicular part. The aquaeductus cochleae has for its medial wall the medial border of the original perilymphatic foramen and the lateral margin of the processus recessus as the lateral border. It may be concluded that the formation of the processus recessus and the conversion of the foramen perilymphaticum into the foramen rotundum and the aquaeductus cochleae in Ovis is in agreement with the observations of these foramina in other mammals.

It will be clear from the above description that the most anterior part of the fissura metotica is usurped into the auditory capsule as the recessus scalae tympani while the posterior part remains back as the foramen jugulare. The foramen is roughly oval in shape surrounded by cartilages on three sides with an opening externally which is directed outwards and backwards. Anteriorly the jugular foramen is limited by the basivestibular commissure, medially by the lateral edge of the basal plate and posteriorly by the base of the occipital arch. The glossopharyngeal, vagus, spinal accessory nerves and the internal jugular vein find their exit from the cranial cavity through this foramen.

The exoccipital cartilages:

The first pair of cartilages to develop are the exoccipital cartilages and these fuse with the supraoccipitals forming a distinct line of fusion in the early stages of development. The lamina alaris which projects over the canalicularis forms the sigmoid sinus and the recess is visible only from the caval surface. The lamina alaris is continued ventrally as the paracondylar process, which is regarded as the transverse process of a vertebral element incorporated into the skull. The paracondylar process is found in most mammals and is confirmed in this work, Lepus (de Beer 1930), Felis (Terry 1917), Sus (Mead 1909), Canis (Olmstead 1911) and Microtus (Fawcett

1917).

The supraoccipital cartilages:

The supraoccipital cartilages which carry the tectum posterius roof only the posterior part of the cranium.

The tectum posterius:

The study of the chondrocranium of Ovis reveals that the tectum posterius is of double origin and becomes fused together in the mid dorsal line as development advances. Two tecta have been observed in man and in cat by Fawcett. In man a broad posterior plate, termed the tectum cranii posterius, and slender isolated pieces of cartilages not connected to the parietal plates and lying anteriorly, termed the tectum cranii anterius, have been noticed. The tectum posterius of Ovis is quite a broad piece of cartilage arching over the posterior region of the cranial cavity. The posterior border of this cartilage forms the vault of the foramen magnum. Its development is in agreement with observations made in calf embryos of 19 m.m. and 40 m.m. stages. There is no tectum cranii anterius in Ovis. Mention should also be made that in Ovis the tectum posterius is connected to the supraoccipitals only and not to the parietal plates.

The Meckel's cartilage:

A detailed description of this cartilage, as observed in this investigation of Ovis, has already been given and it only remains to mention the various stages in which the symphysis is formed. The cartilage appears in the 18 m.m.

C.R.L. embryo as a short rod away from the auditory capsule in the ventral region of the orbito-temporal part. In the 21 m.m. C.R.L. embryo the length increases considerably but still the cartilages of both sides are wide apart anteriorly. The 26 m.m. C.R.L. embryo shows these cartilages approximating towards each other in the anterior region but as yet being separated by a narrow gap. The 19 m.m. head height embryo shows the two cartilages fused together forming the symphysis.

The Reichert's cartilage:

The Reichert's cartilage is composed of two parts namely stylohyal and laterohyal. The first cartilage to develop is the stylohyal seen in a 21 m.m. C.R.L. embryo as a short rod placed far away from the auditory capsule. The laterohyal appears in a 26 m.m. C.R.L. embryo dorsal to the stylohyal and very near to the auditory capsule. There is as yet no fusion of the laterohyal with the capsule. In the next stage the laterohyal is not only in contact with the crista parotica of the auditory capsule above, but also with the dorsal extremity of the stylohyal. Thus, the two components of the Reichert's cartilage have been observed to develop separately in Ovis and to fuse together to form a single cartilage. This is in agreement with the observations of de Beer and Fuchs in Lepus.

The earliest stage of specimen to show the membrane bones in their feeble state of development is that of the 13 m.m. H.H. The dentary is in a fairly advanced stage of development. It has been established by many previous authors that the dentary is the first membrane bone to develop and so is seen as a flat piece of bone extending along the Meckel's cartilage. The growth of this bone has been closely followed in this study and the following observations may be made. The Meckel's cartilage takes no part in the formation of the mandible, it serves only as a supporting rod to the developing dentary. The dentary is composed of two lamellae, the medial and the lateral which develop at different rates. The medial lamella grows more slowly than the lateral and is seen attaining its full length in a specimen of 22 m.m. H.H. Further growth in the length of the bone is affected by the extension of the osteogenetic fibres. The mandibular symphysis does not occur till late in the development of the osteocranium. The development of the condyle is preceded by the coronoid process.

Another interesting feature that can be noted from this study is the speed with which the frontal and the parietal bones develop to protect the vital part of the central nervous system.

The interparietals were observed to ossify from a paired centre posterior to the parietals. The preinter-parietal centres found occasionally in Bos, Canis and Man were not seen in any specimens of Ovis.

Of the facial bones the maxilla is the first to attain a considerable size. The nasal process (ascending process) of the premaxilla develops first and it takes quite some time for the body and the palatine process to develop. Gaupp (1906) and Schwink (1888) observed that the palatine process of the premaxilla in Ovis had a separate centre of ossification and became fused to the process directed backwards from the body of the premaxilla. The present study shows the palatine process of the premaxilla already attached to the body and at no stage has it been observed to exist as an independent structure. As a matter of fact both the body and the palatine process were seen appearing together in the 22 m.m. H.H. specimen. It may be said that the palatine process of the premaxilla represents the prevomer of the earlier forms which have lost their individuality.

The first part of the pterygoid bone to appear in Ovis is the hamular process in a 17 m.m. H.H. specimen followed by the internal pterygoid plate, whereas in man Fawcett (1905 and 1910 A and B) has described the internal pterygoid bone as ossifying earlier than the hamular process. Though the membranous part of the pterygoid bone is well formed, the pterygoid cartilage of the ala temporalis remains unossified for some time showing that the pterygoid bone of the adult is a combined structure of two distinct pieces of bone derived from different origins, membranous and cartilaginous. This observation is in accordance with those of Broom (1914), Gaupp (1901), Fuchs (1909), Kampen (1922), Terry (1917), Fawcett (1905) and Lubosch (1907) in other mammals.

It is a point worthy of note that of the cartilage bones the Reichert's cartilage is the first to ossify though it is formed much later than the other cartilages of the chondrocranium. This is followed by the occipitals. The alisphenoid (wing of the postsphenoid) ossifies earlier than the basipostsphenoid. It is in the shape of a fork with the processus alaris serving as a handle. Soon the basipostsphenoid appears and the foramen ovale is surrounded by bone on all sides. The mandibular branch of the trigeminal nerve passes through this foramen. Another important fact which draws our attention is the absence of ossification of the basipresphenoid though the orbito-sphenoid (wing of the presphenoid) ossifies simultaneously with that of the alisphenoid.

The supraoccipital of Ovis ossifies from a median unpaired centre in the tectum posterius. This is in agreement with the observations of Lacoste (1927) in Ovis, Drews (1933) in Felis, Augier (1934a) in Sus, whereas in Bos, Augier (1931b) and Canis, Drews (1933), it arises from paired centres.

The posterior extremity of the Meckel's cartilage is the first of the auditory ossicles to show signs of ossific-ation. Though it is not intended to give a detailed description of the origin of these bones it may be said that the malleus, incus and stapes of mammals are homologues with the articular, quadrate and columella auris of reptiles.

It may be mentioned in conclusion that though the chondrocranium develops as a scaffolding material for the future building of the osteocranium, it is not till late in the development of the membrane bones that the ossific centres appear in the various cartilages of the chondrocranium. The charts appended at the end of the thesis show at a glance the various stages of ossification according to the appearance of the ossific centres.

Conclusion

Under the modern method of investigation adopted in the present study of the chondrocranium of Ovis the following conclusions may be drawn. The chondrocranium of Ovis conforms to the generalized mammalian type and could be easily derived from the reptilian ancestors. Many features characteristic of placental mammals are clearly exhibited The following are some of the interesting features which draw attention.

1) The constricted basal plate differs from the wide basal plate of reptilian origin as in Bos and Equus.
2) The presence of the interorbital septum suggests the the tropibasic skull of reptilian ancestors.
3) Two pairs of hypoglossal foramina are present.
4) There is no processus ascendens and the ala temporalis is a separate cartilage. The presence of an outer bar of Jacobson's cartilage appears to provide an intermediate group bridging Archaeorhinata and Caenorhinata.
5) There is a definite backward extension of the nasal capsule.
6) The sphenethmoid commissures are slender rods, the orbito-parietal commissures are broad reminiscent of amphibian ancestors.
7) The chondrocranium of Ovis conforms to the placental type of chondrocranium.
8) The base of the cranium takes a long period to ossify though a cartilaginous foundation is laid early in the

development.

9) The basipresphenoid and the auditory capsules do not ossify till late in development.

10) The Meckel's cartilage takes no part in the formation of the mandible except to serve as a supporting rod for the lamellae of the dentary.

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Explanation of Lettering

A - Auditory capsule

ACC - Alicochlear commissure

ACTC - Anterior cornua of thyroid cartilage

AH - Ala hypochiasmatica

ALI - Alisphenoid bone

AMASC - Ampulla anterior semicircular canal

AMLSC - Ampulla lateral semicircular canal

AMPSC - Ampulla posterior semicircular canal

ASC - Anterior semicircular canal

AT - Ala temporalis

ATN - Neural arch of atlas vertebra

ATP - Pleurocentrum of atlas vertebra

ATT - Atrioturbinal

AXN - Neural arch of axis vertebra

AXP - Pleurocentrum of axis vertebra

BCC - Basicochlear commissure

BCF - Basicochlear fissure

BF - Basicranial fenestra

BH - Basihyal cartilage

BO - Basioccipital bone

BPMX - Body of premaxillary bone

BS - Basisphenoid bone

BVC - Basivestibular commissure

CAA - Crista ampullaris anterior

CAL - Crista ampullaris lateral

CAP - Crista ampullaris posterior

CAT - Cavum tympani

CC - Canalicular part of auditory capsule

CD - Cochlear duct

CDN - Cartilago ductus nasopalatini

CH - Ceratohyal

COC - Cochlear part of auditory capsule

COP - Orbito-parietal commissure

CP - Coronoid process

CRG - Crista galli

CRL - Crown rump length

CRP - Crista parotica

CSE - Sphenethmoid commissure

CT - Crista transversa

DEN - Dentary bone

DLNG - Duct of lateral nasal gland

DS - Dorsum sellae

E - Eyeball

ED - Endolymphatic duct

ET - Ethmoturbinal

EXO - Exoccipital bone

FAC	-	Foramen acusticum
FAI	-	Foramen acusticum inferior
FAS	-	Foramen acusticum superior
FC	-	Carotid foramen
FCR	-	Fenestra cribrosa
FE	-	Foramen epiphaniale
FEN	-	Foramen endolymphaticum
FF	-	Foramen for facial nerve
FH	-	Hypophyseal fenestra
FIO	-	Infraorbital foramen
FJ	-	Foramen jugulare
FLP	-	Fissura lamina parietalis
FM	-	Foramen magnum
FN	-	Fenestra narina
FO	-	Optic foramen
FOC	-	Fissura occipito-capsularis
FOI	-	Fissura occipito-capsularis inferior
FOS	-	Fissura occipito-capsularis superior
FOV	-	Fenestra ovalis
FP	-	Foramen perilymphaticum
FR	-	Foramen rotundum
FRO	-	Frontal bone
FSAE	-	Fossa subarcuata externa
FSAI	-	Fossa subarcuata interna
FSI	-	Fossa incudis
FT	-	Frontoturbinal

GGEN - Ganglion geniculata

GS - Ganglion semilunar

H - Hypophysis

HB - Hyoid bone

HC - Hypophyseal cartilage

HF - Hypoglossal foramen

HH - Hypohyal

I - Incus

IC - Internal carotid

IOS - Interorbital septum

JO - Jacobson's organ

JUG - Jugal bone

JV - Jugular vein

LA - Lamina ascendens

LAC - Lachrymal bone

LAM INF CON - Lamina infraconchalis

LC - Lamina cribrosa

LH - Laterohyal

LON - Lamina orbito-nasalis

LPC - Lateral prefacial commissure

LSC - Lateral semicircular canal

LTA - Lamina transversalis anterior

LTP - Lamina transversalis posterior

M - Malleus

MAE - Meatus acusticus externus

MAX - Maxillary bone

MC - Meckel's cartilage

MF - Mental foramen

MP - Mastoid process

MR - Metoptic root of orbital cartilage

MT - Maxillo-turbinal

MXP - Palatine process of maxilla

MXZ - Zygomatic process of maxilla

N - Notochord

NAS - Nasal bone

NC - Nasal capsule

NLD - Nasolachrymal duct

NPD - Nasopalatine duct

NPMX - Nasal process of premaxillary bone

NS - Nasal septum

NT - Nasoturbinal

OA - Occipital arch

OC - Occipital condyle

OF - Orbital plate of frontal bone

ON - Optic nerve

ONF - Orbito-nasal fissure

ORC - Orbital cartilage

ORS - Orbito-sphenoid

P	-	Parachordal or Basal plate
PAB	-	Palatine bone
PAC	-	Palatine cartilage
PAI	-	Processus alaris inferior
PAR	-	Parietal bone
PAS	-	Processus alaris superior
PCC	-	Parieto-capsular commissure
PCP	-	Paracondylar process
PCS	-	Palatine commissure
PFC	-	Prefacial commissure
PMX	-	Premaxillary bone
PN	-	Paranasal cartilage
PNS	-	Paries nasi
PPL	-	Parietal plate
PR	-	Preoptic root of orbital cartilage
PRASC	-	Prominence anterior semicircular canal
PRR	-	Processus recessus
PRS	-	Presphenoid
PS	-	Paraseptal cartilage
PSC	-	Posterior semicircular canal
PSP	-	Posterior paraseptal cartilage
PT	-	Parietotectal cartilage
PTG	-	Pterygoid bone
PTP	-	Pterygoid process
PV	-	Prevomer bone
PVP	-	Palatine process of premaxilla

RC - Reichert's cartilage

RF - Recessus frontalis

RJ - Recessus jugulare

RM - Recessus maxillaris

S - Stapes

SCC - Sphenocochlear commissure

SH - Stylohyal cartilage

SOB - Supraoccipital bone

SOC - Supraoccipital cartilage

SQ - Squamosal bone

SPF - Sphenoparietal fontanella

SSP - Septum spirale

SSS - Sulcus supraseptalis

T - Central stem

TC - Thyroid cartilage

TCA - Anterior wing of thyroid cartilage

TCP - Posterior wing of thyroid cartilage

TEN TY - Tensor tympani

TG - Tongue

TH - Thyrohyal cartilage

TN - Tectum nasi

TP - Tectum posterius

TR - Tracheal ring

TTY - Tegmen tympani

TY - Tympanic bone

U - Utricle

VB - Vomer bone

Chronology of the Ossification Centres

in the Skull of Ovis

Membrane Bones of the Cranium

Chronology of the Ossification Centres in the Skull of Ovis

Cartilage Bones of the Cranium

Stage Nos.	I	II	III	IV	V	VI	VII	VIII
Head Height in m.m.	13 m.m.	14 m.m.	16 m.m.	17 m.m.	19 m.m.	22 m.m.	25 m.m.	31 m.m.
Exoccipital condyle				■	■	■	■	■
Basioccipital					■	■	■	■
Occipital arch							■	■
Basi postsphenoid					■	■	■	■
Alisphenoid					■	■	■	■
Basi presphenoid								
Orbitosphenoid					■	■	■	■
Ethmoid								
Hyoid			■	■	■	■	■	■

Chronology of the Ossification Centres
in the Skull of Ovis

Membrane Bones of the Face

Stage Nos.	I	II	III	IV	V	VI	VII	VIII
Head Height in m.m.	13 m.m.	14 m.m.	16 m.m.	17 m.m.	19 m.m.	22 m.m.	25 m.m.	31 m.m.
Pterygoid (body)					■	■	■	■
Pterygoid (Hamular process)				■	■	■	■	■
Palatine		■	■	■	■	■	■	■
Premaxilla (body)						■	■	■
Premaxilla (ascending process)			■	■	■	■	■	■
Premaxilla (palatine process)						■	■	■
Maxilla (body)	■	■	■	■	■	■	■	■
Maxilla (palatine process)		■	■	■	■	■	■	■
Nasal					■	■	■	■
Lachrymal			■	■	■	■	■	■
Jugal (Malar)	■	■	■	■	■	■	■	■
Vomer					■	■	■	■

Chronology of the Ossification Centres
in the Skull of Ovis

Membrane Bones of the Face

Stage Nos.	I	II	III	IV	V	VI	VII	VIII
Head Height in m.m.	13 m.m.	14 m.m.	16 m.m.	17 m.m.	19 m.m	22 m.m.	25 m.m.	31 m.m.
Pterygoid (body)					■	■	■	■
Pterygoid (Hamular process)				■	■	■	■	■
Palatine		■	■	■	■	■	■	■
Premaxilla (body)						■	■	■
Premaxilla (ascending process)			■	■	■	■	■	■
Premaxilla (palatine process)						■	■	■
Maxilla (body)	■	■	■	■	■	■	■	■
Maxilla (palatine process)		■	■	■	■	■	■	■
Nasal					■	■	■	■
Lachrymal			■	■	■	■	■	■
Jugal (Malar)	■	■	■	■	■	■	■	■
Vomer					■	■	■	■

Fig. I

Stage I

A 13 - 15 mm. C.R.L.

Dorsal View

ATN - Neural arch of atlas vertebra.

ATP - Pleurocentrum of atlas vertebra.

AXN - Neural arch of axis vertebra.

AXP - Pleurocentrum of axis vertebra .

N - Notochord.

OA - Occipital arch.

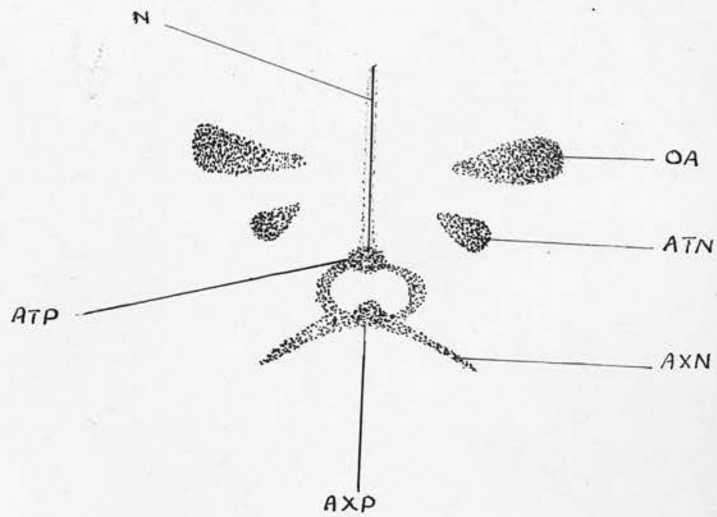

Fig. I

Stage I

A 13 - 15 mm. C.R.L.

Dorsal View

Fig. II

Stage I

A 13 - 15 mm. C.R.L.

Lateral View

ATN - Neural arch of atlas vertebra.

AXN - Neural arch of axis vertebra.

CC - Canalicular part of auditory capsule.

OA - Occipital arch.

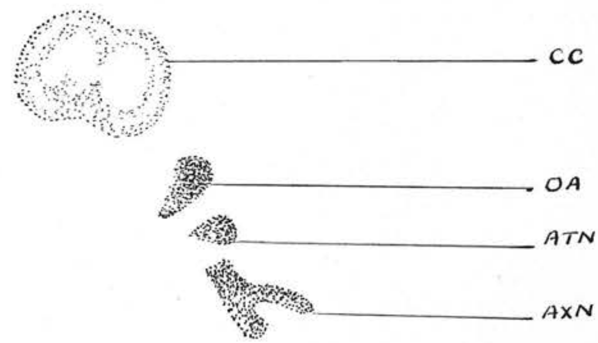

Fig. II

Stage I

A 13 - 15 mm. C.R.L.

Lateral View

Fig. III

Stage II

C 8 - 20 mm. C.R.L.

Dorsal View

ATN - Neural arch of atlas vertebra.

ATP - Pleurocentrum of atlas vertebra.

AXN - Neural arch of axis vertebra.

AXP - Pleurocentrum of axis vertebra.

HF - Hypoglossal foramen.

N - Notochord.

OA - Occipital arch.

P - Parachordal or basal plate.

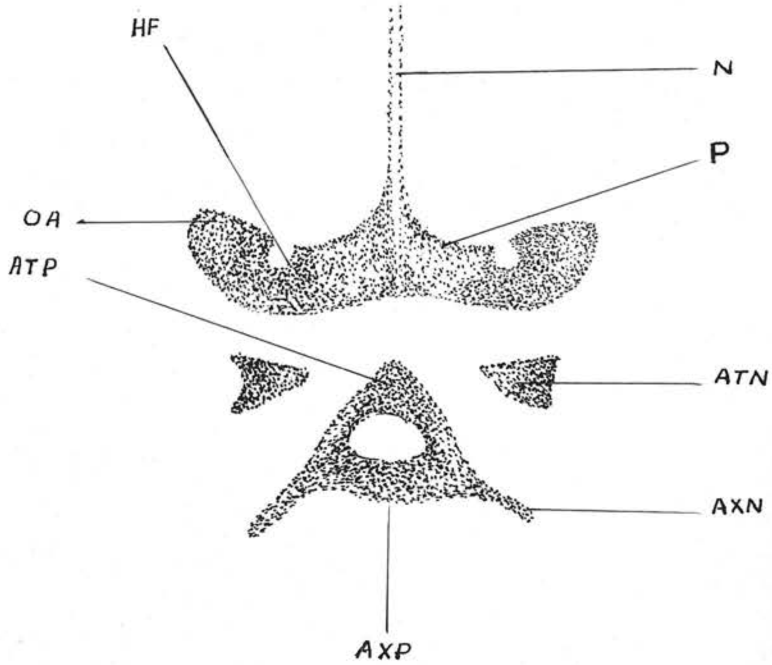

Fig. III

Stage II

C 8 - 20 mm. C.R.L.

Dorsal View

Fig. IV

Stage III

A 12 - 18 mm. C.R.L.

Dorsal View

ATN - Neural arch of atlas vertebra.

AXN - Neural arch of axis vertebra.

HC - Hypophyseal cartilage.

HF - Hypoglossal foramen.

N - Notochord.

OA - Occipital arch.

T - Central stem (Trabecular plate).

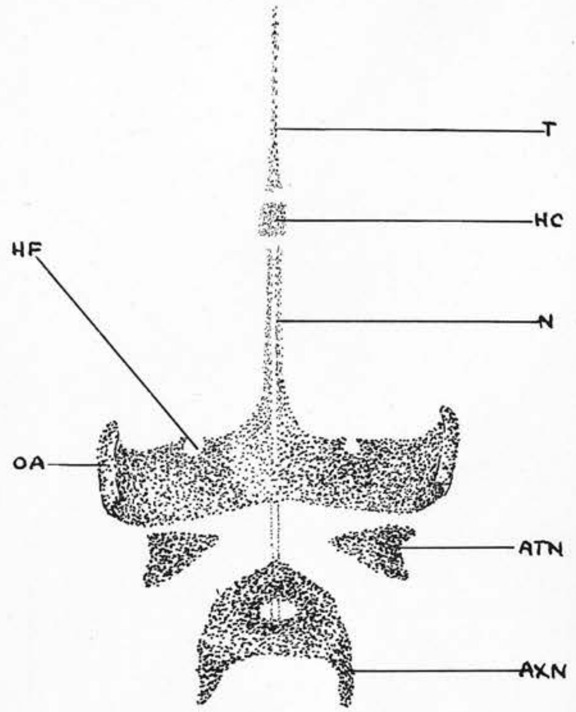

Fig. IV

Stage III

A 12 - 18 mm. C.R.L.

Dorsal View

Fig. V

<u>Stage III</u>

A 12 - 18 mm. C.R.L.

Lateral View

ATN - Neural arch of atlas vertebra.

AXN - Neural arch of axis vertebra.

CC - Canalicular part of auditory capsule.

OA - Occipital arch.

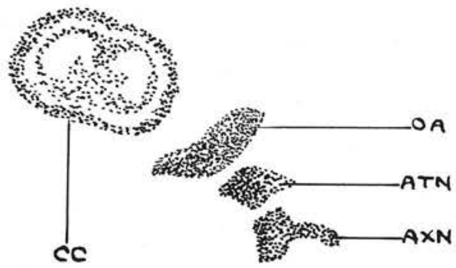

Fig. V

Stage III

A 12 - 18 mm. C.R.L.

Lateral View

Fig. VI

Stage IV

C 10 - 18 mm. C.R.L.

Dorsal View

ATN - Neural arch of atlas vertebra.

AXN - Neural arch of axis vertebra.

CC - Canalicular part of auditory capsule.

HC - Hypophyseal cartilage.

HF - Hypoglossal foramen.

N - Notochord.

OA - Occipital arch.

P - Parachordal or basal plate.

T - Central stem (Trabecular plate)

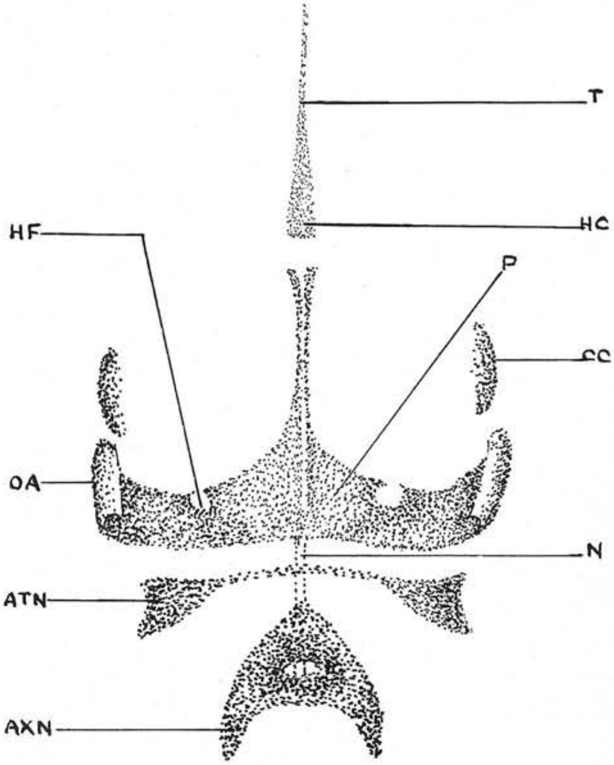

Fig. VI

Stage IV

C 10 - 18 mm. C.R.L.

Dorsal View

Fig. VII

Stage IV

C 10 - 18 mm. C.R.L.

Lateral View

ATN - Neural arch of atlas vertebra.

AXN - Neural arch of axis vertebra.

CC - Canalicular part of auditory capsule.

MC - Meckel's cartilage.

OA - Occipital arch.

P - Parachordal or basal plate.

T - Central stem (Trabecular plate).

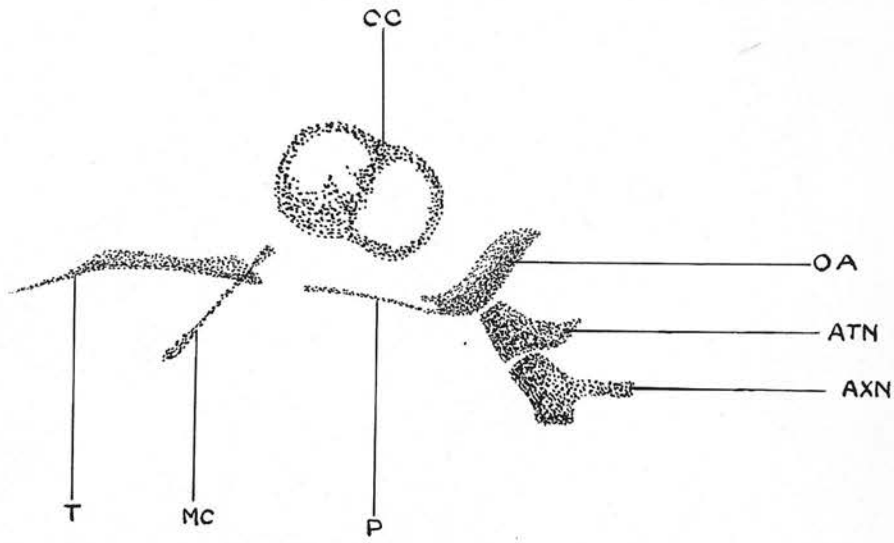

Fig. VII

Stage IV

C 10 - 18 mm. C.R.L.

Lateral View

Fig. VIII

Stage V

C 14 - 23 mm. C.R.L.

Dorsal View

ATN - Neural arch of atlas vertebra.

ATP - Pleurocentrum of atlas vertebra.

AXN - Neural arch of axis vertebra.

CC - Canalicular part of auditory capsule.

HC - Hypophyseal cartilage.

HF - Hypoglossal foramen.

N - Notochord.

OA - Occipital arch.

P - Parachordal or basal plate.

T - Central stem (Trabecular plate).

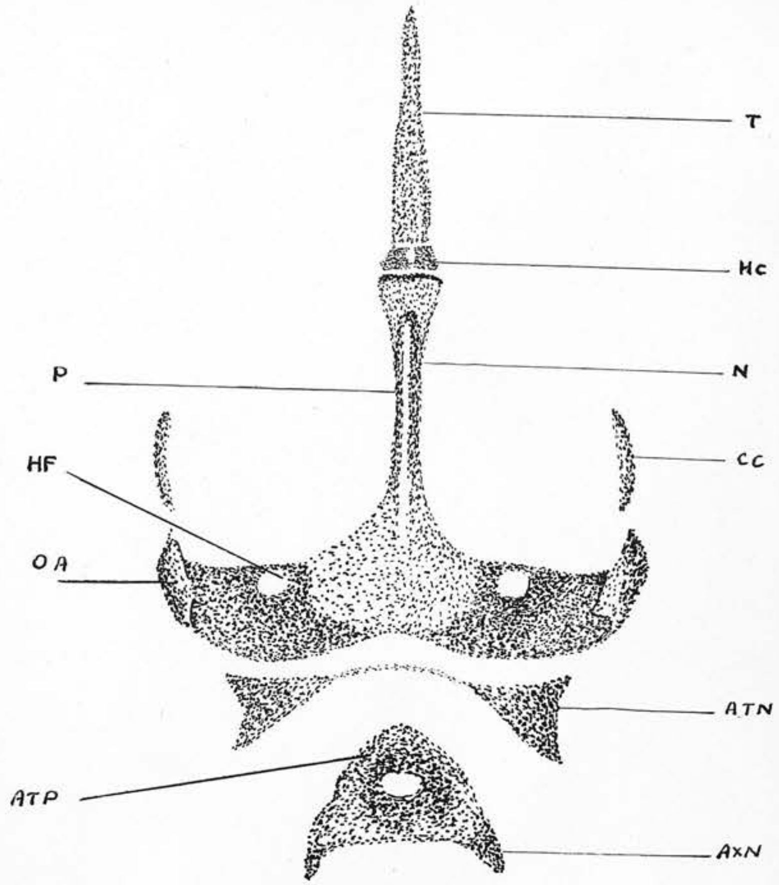

Fig. VIII

Stage V

C_{14} - 23 mm. C.R.L.

Dorsal View

Fig. IX

Stage V

C 14 - 23 mm. C.R.L.

Lateral View

ATN - Neural arch of atlas vertebra.

AXN - Neural arch of axis vertebra.

CC - Canalicular part of auditory capsule.

HC - Hypophyseal cartilage.

OA - Occipital arch.

P - Parachordal or basal plate.

T - Central stem (Trabecular plate).

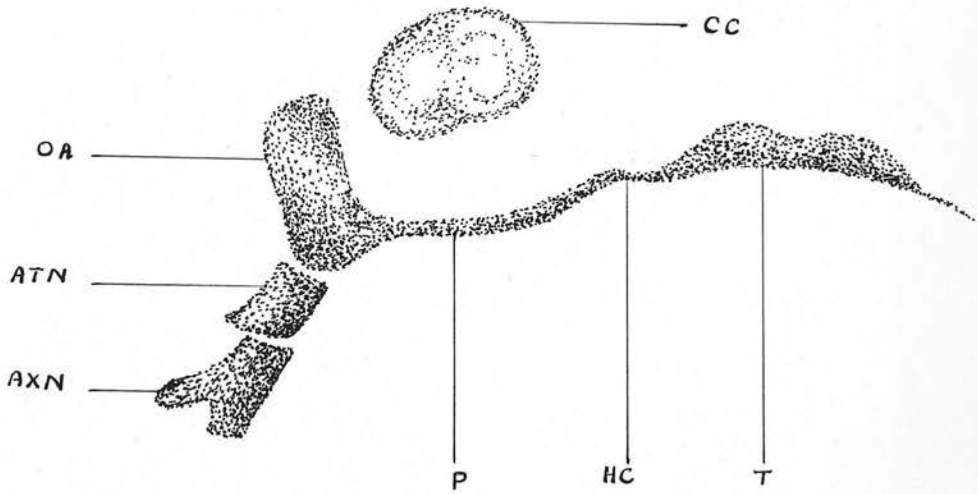

Fig. IX

Stage V

C_{14} - 23 mm. C.R.L.

Lateral View

Fig. X

Stage VI

A 5 - 21 mm. C.R.L.

Dorsal View

ATN - Neural arch of atlas vertebra.

AXN - Neural arch of axis vertebra.

CC - Canalicular part of auditory capsule.

CT - Crista transversa.

HC - Hypophyseal cartilage.

HF - Hypoglossal foramen.

LON - Lamina orbito-nasalis.

MR - Metoptic root of orbital cartilage.

N - Notochord.

NS - Nasal septum.

P - Parachordal or basal plate.

PN - Paranasal cartilage.

SOC - Supraoccipital cartilage.

T - Central stem (Trabecular plate).

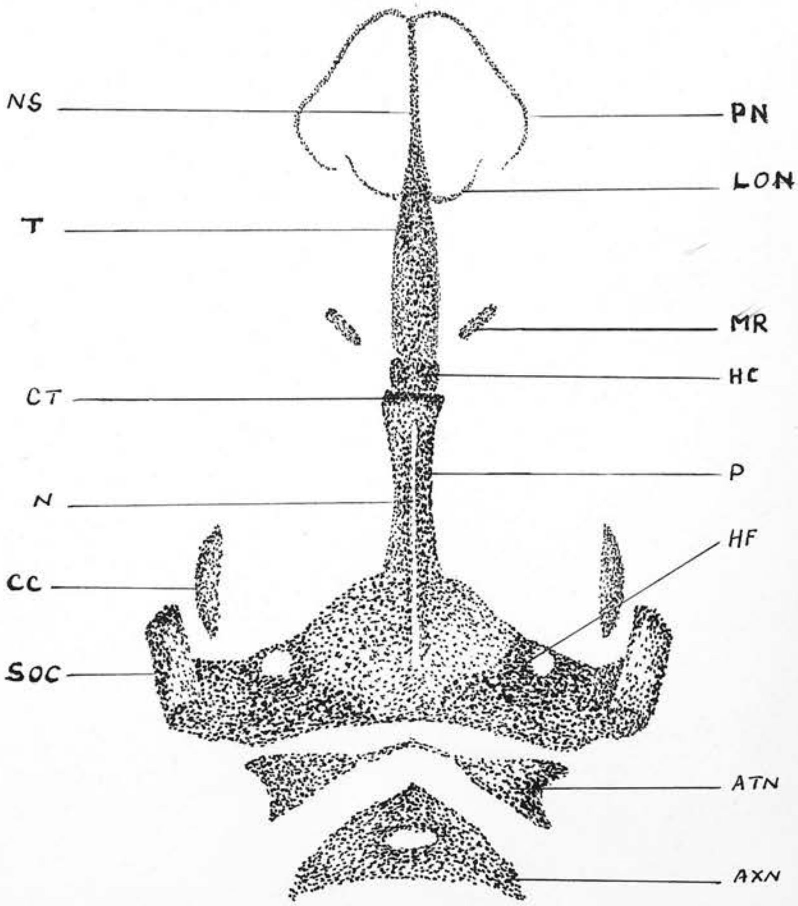

Fig. X

Stage VI

A_5 - 21 mm. C.R.L.

Dorsal View

Fig. XI

Stage VI

A 5 - 21 mm. C.R.L.

Lateral View

ATN - Neural arch of atlas vertebra.

CC - Canalicular part of auditory capsule.

CRP - Crista parotica.

FE - Foramen epiphaniale.

MC - Meckel's cartilage.

MR - Metoptic root of orbital cartilage.

OA - Occipital arch.

PCP - Paracondylar process.

PN - Paranasal cartilage.

SH - Stylohyal cartilage.

SOC - Supraoccipital cartilage.

TN - Tectum nasi.

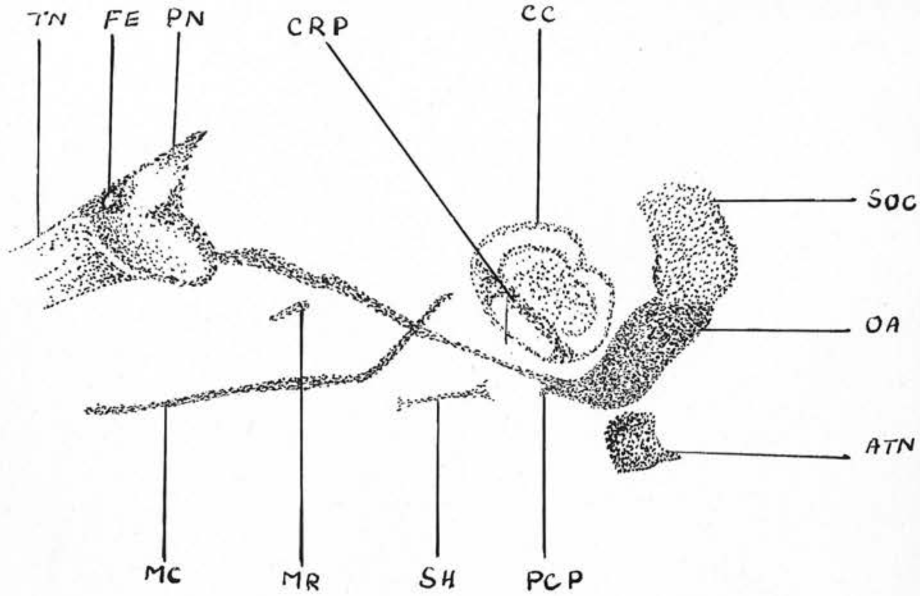

Fig. XI

Stage VI

A_5 - 21 mm. C.R.L.

Lateral View.

Fig. XII

Stage VII

C 1 - 26 mm. C.R.L.

Dorsal View

AT - Ala temporalis.

CC - Canalicular part of auditory capsule.

FC - Carotid foramen.

HC - Hypophyseal cartilage.

LON - Lamina orbito-nasalis.

MR - Metoptic root of orbital cartilage.

N - Notochord.

NS - Nasal septum.

OA - Occipital arch.

PN - Paranasal cartilage.

PR - Preoptic root of orbital cartilage.

SOC - Supraoccipital cartilage.

TN - Tectum nasi.

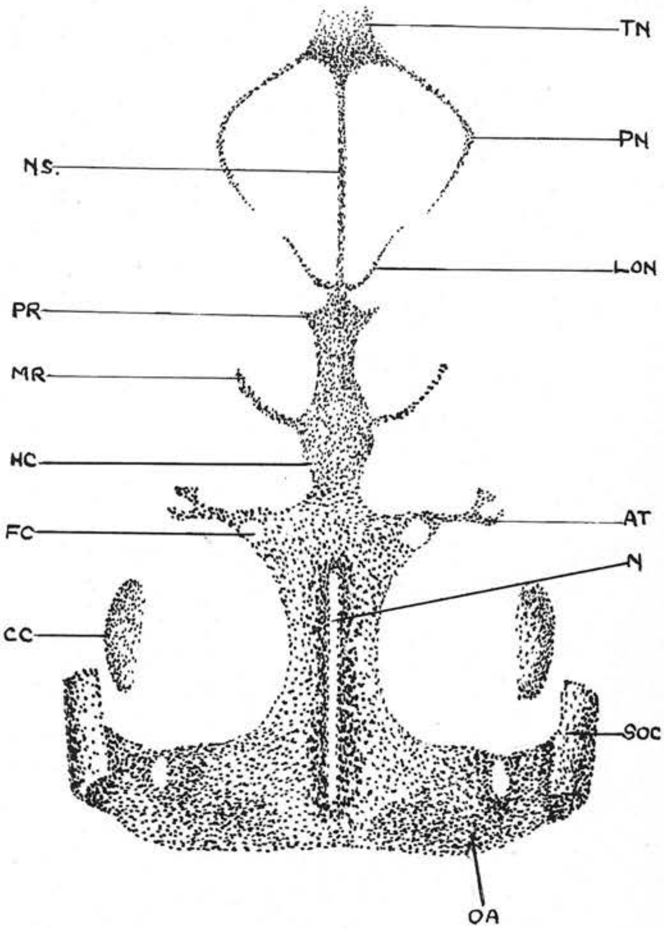

Fig. XII

Stage VII

C_1 - 26 mm. C.R.L.

Dorsal View

Fig. XIII

Stage VII

C 1 - 26 mm. C.R.L.

Lateral View

AT - Ala temporalis.

CC - Canalicular part of auditory capsule.

LH - Laterohyal.

M - Malleus.

MC - Meckel's cartilage.

MR - Metoptic root of orbital cartilage.

OA - Occipital arch.

PCP - Paracondylar process.

PN - Paranasal cartilage.

PR - Preoptic root of orbital cartilage.

SH - Stylohyal cartilage.

SOC - Supraoccipital cartilage.

TN - Tectum nasi.

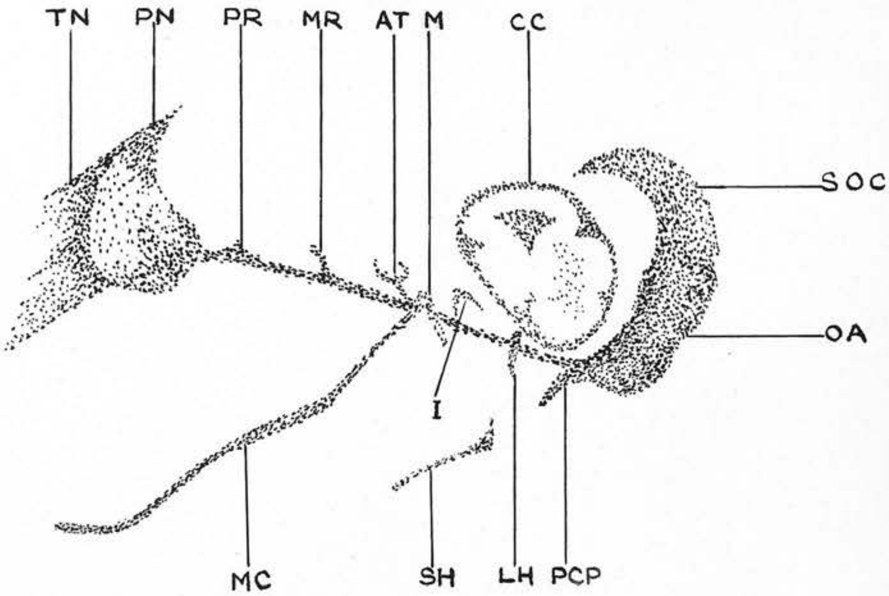

Fig. XIII

Stage VII

C_1 - 26 mm. C.R.L.

Lateral View

Fig. XIV

Stage VII

C 1 - 26 mm. C.R.L.

Ventral View

MC - Meckel's cartilage.

SH - Stylohyal cartilage.

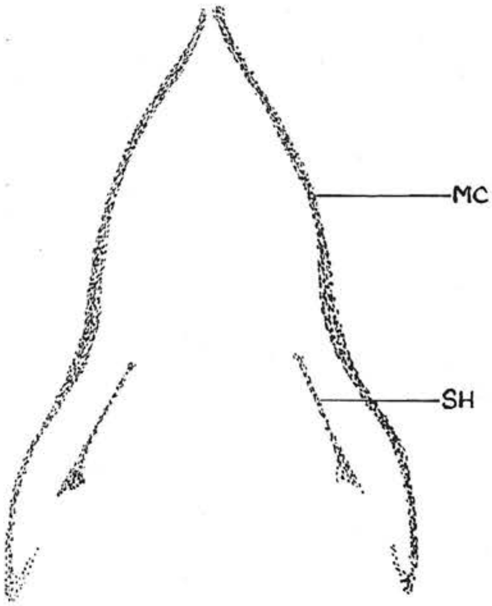

Fig. XIV.

Stage VII

C_1 - 26 mm. C.R.L.

Ventral View.

Fig. XV

Stage VII

C 1 - 26 mm. C.R.L.

Lateral View of the Auditory Capsule

CC - Canalicular part of auditory capsule.

FJ - Foramen jugulare.

FOC - Fissura occipito-capsularis.

FOI - Fissura occipito-capsularis inferior.

FOS - Fissura occipito-capsularis superior.

I - Incus.

LH - Laterohyal.

M - Malleus.

MC - Meckel's cartilage.

OA - Occipital arch.

PCP - Paracondylar process.

SH - Stylohyal cartilage.

SOC - Supraoccipital cartilage.

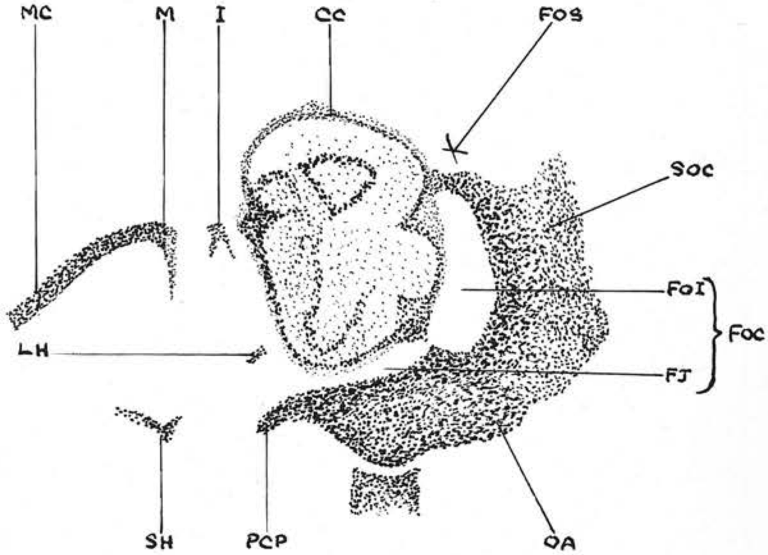

Fig. XV

Stage VII

C 1 - 26 mm. C.R.L.

Lateral View of the Auditory Region

Fig. XVI

Stage VII

C 1 - 26 mm. C.R.L.

Dorsal View of the Hypophyseal Region

ACC - Alicochlear commissure.

AT - Ala temporalis.

FC - Carotid foramen.

HC - Hypophyseal cartilage.

N - Notochord.

P - Parachordal or basal plate.

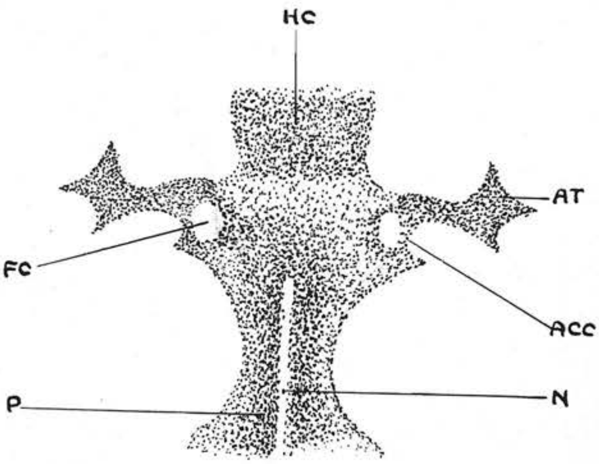

Fig. XVI

Stage VII

C 1 - 26 mm. C.R.L.

Dorsal View of the Hypophyseal Region.

Fig. XVII

Stage VIII

A 7 - 20 mm. C.R.L.

Dorsal View

AT - Ala temporalis.

CC - Canalicular part of auditory capsule.

FO - Optic foramen.

HC - Hypophyseal cartilage.

HF - Hypoglossal foramen.

LON - Lamina orbito-nasalis.

MR - Metoptic root of orbital cartilage.

N - Notochord.

NS - Nasal septum.

OA - Occipital arch.

ORC - Orbital cartilage.

P - Parachordal or basal plate.

PN - Paranasal cartilage.

PR - Preoptic root of orbital cartilage.

SOC - Supraoccipital cartilage.

TN - Tectum nasi.

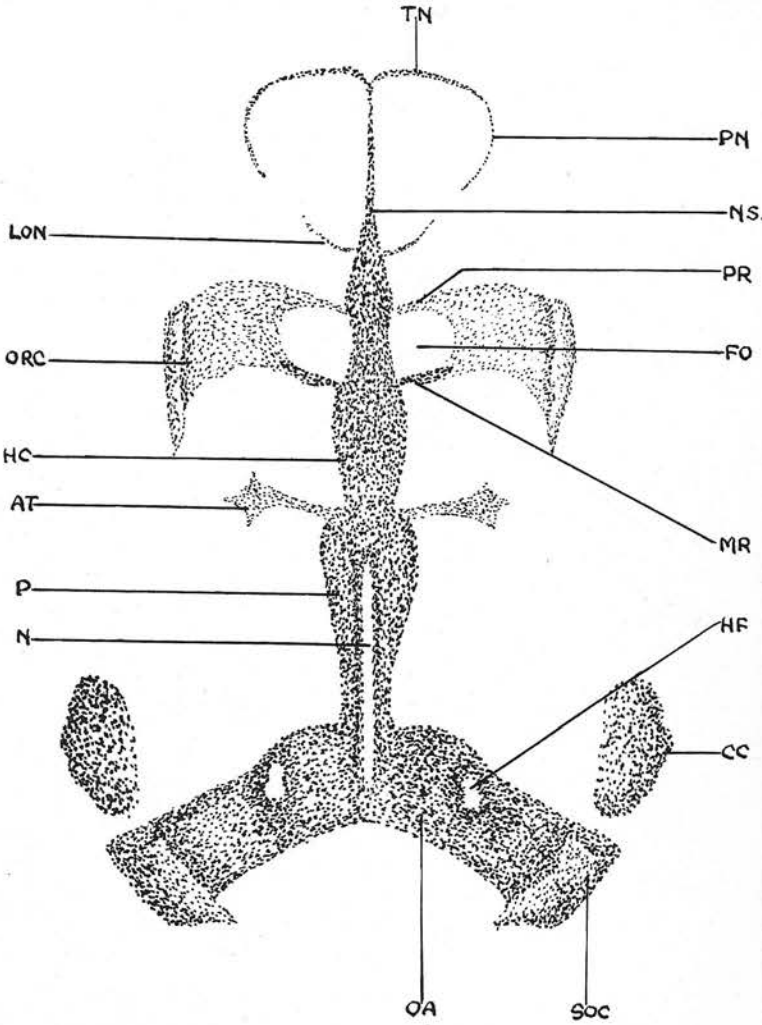

Fig. XVII

Stage VIII

A 7 - 20 mm. C.R.L.

Dorsal View

Fig. XVIII

Stage VIII

A 7 - 20 mm. C.R.L.

Lateral View

CC - Canalicular part of auditory capsule.

FO - Optic foramen.

I - Incus.

LH - Laterohyal.

M - Malleus.

MC — Meckel's cartilage

MR - Metoptic root of orbital cartilage.

OA - Occipital arch.

ORC - Orbital cartilage.

PCP - Paracondylar process.

PN - Paranasal cartilage.

PR - Preoptic root of orbital cartilage.

SH - Stylohyal cartilage.

SOC - Supraoccipital cartilage.

TN - Tectum nasi.

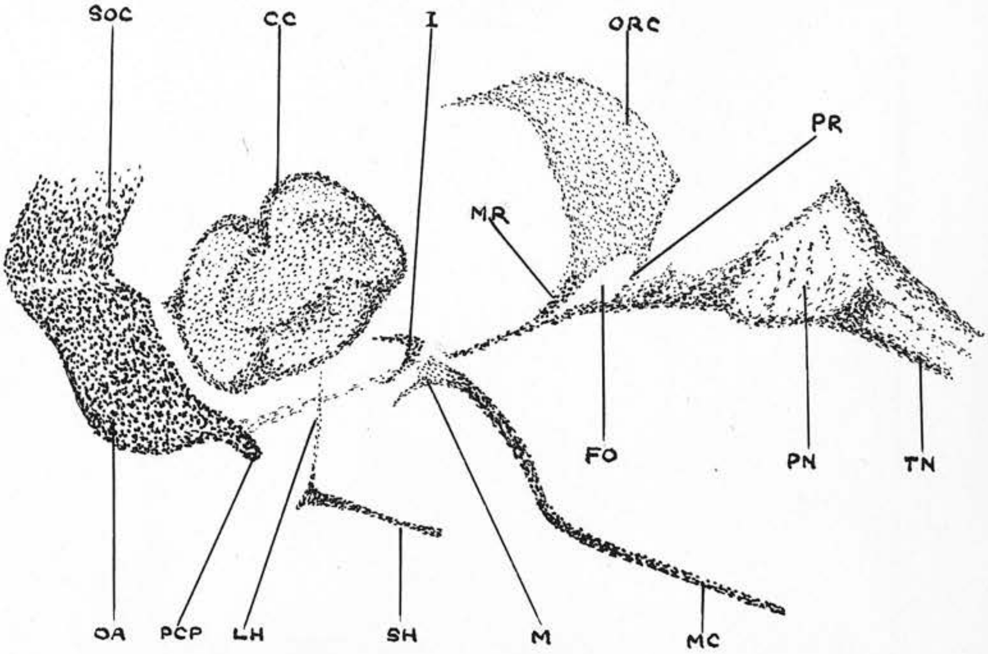

Fig. XVIII Stage VIII

A 7 - 20 mm. C.R.L.

Lateral View

Fig. XIX

Stage VIII

A 7 - 20 mm. C.R.L.

Ventral View. Splanchnoskeleton.

I - Incus.

LH - Laterohyal.

M - Malleus.

MC - Meckel's cartilage.

SH - Stylohyal cartilage.

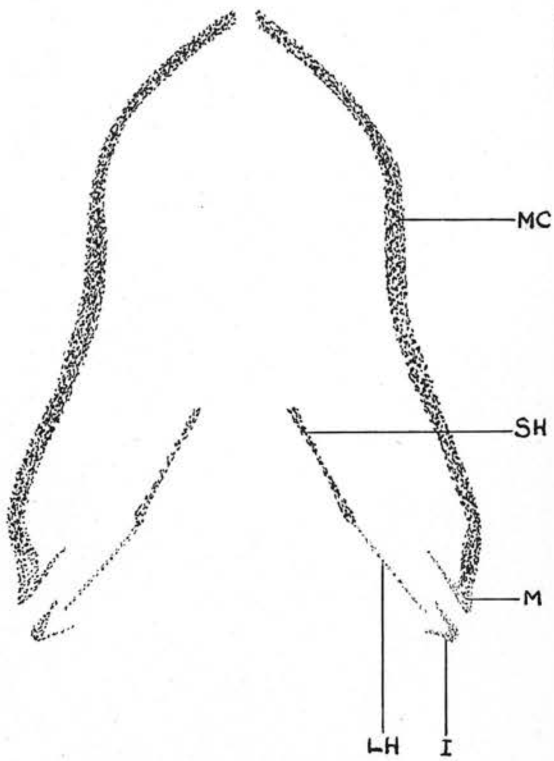

Fig. XIX Stage VIII

A 7 - 20 mm. C.R.L.
Ventral View. Splanchnoskeleton.

Fig. XX

Stage VIII

A 7 - 20 mm. C.R.L.

Ventral View

AT - Ala temporalis.

CC - Canalicular part of auditory capsule.

FO - Optic foramen.

HF - Hypoglossal foramen.

LON - Lamina orbito-nasalis.

MR - Metoptic root of orbital cartilage.

NS - Nasal septum.

OA - Occipital arch.

ORC - Orbital cartilage.

P - Parachordal or basal plate.

PN - Paranasal cartilage.

SOC - Supraoccipital cartilage.

TN - Tectum nasi.

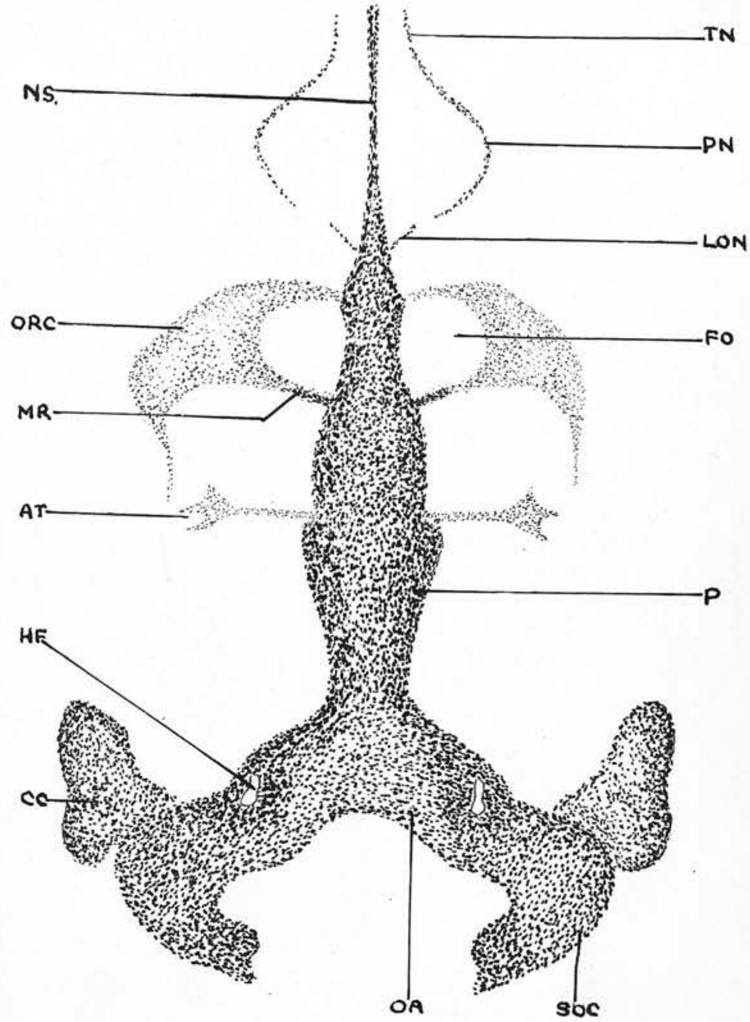

Fig. XX

Stage VIII

Ventral View
A 7 - 20 mm. C.R.L.

Fig. XXI

Stage IX

A 1 - 28 mm. C.R.L.

Dorsal View

ACC - Alicochlear commissure.

BCF - Basicochlear fissure.

BVC - Basivestibular commissure.

CC - Canalicular part of auditory capsule.

COC - Cochlear part of auditory capsule.

COP - Orbito-parietal commissure.

FH - Hypophyseal fenestra.

FO - Optic foramen.

FM - Foramen magnum.

HC - Hypophyseal cartilage.

HF - Hypoglossal foramen.

LA - Lamina ascendens.

LON - Lamina orbito-nasalis.

MR - Metoptic root of orbital cartilage.

ORC - Orbital cartilage.

P - Parachordal or basal plate.

PN - Paranasal cartilage.

PR - Preoptic root of orbital cartilage.

PTP - Pterygoid process.

PT - Parietotectal cartilage.

SCC - Sphenocochlear commissure.

T - Central stem.

TP - Tectum posterius.

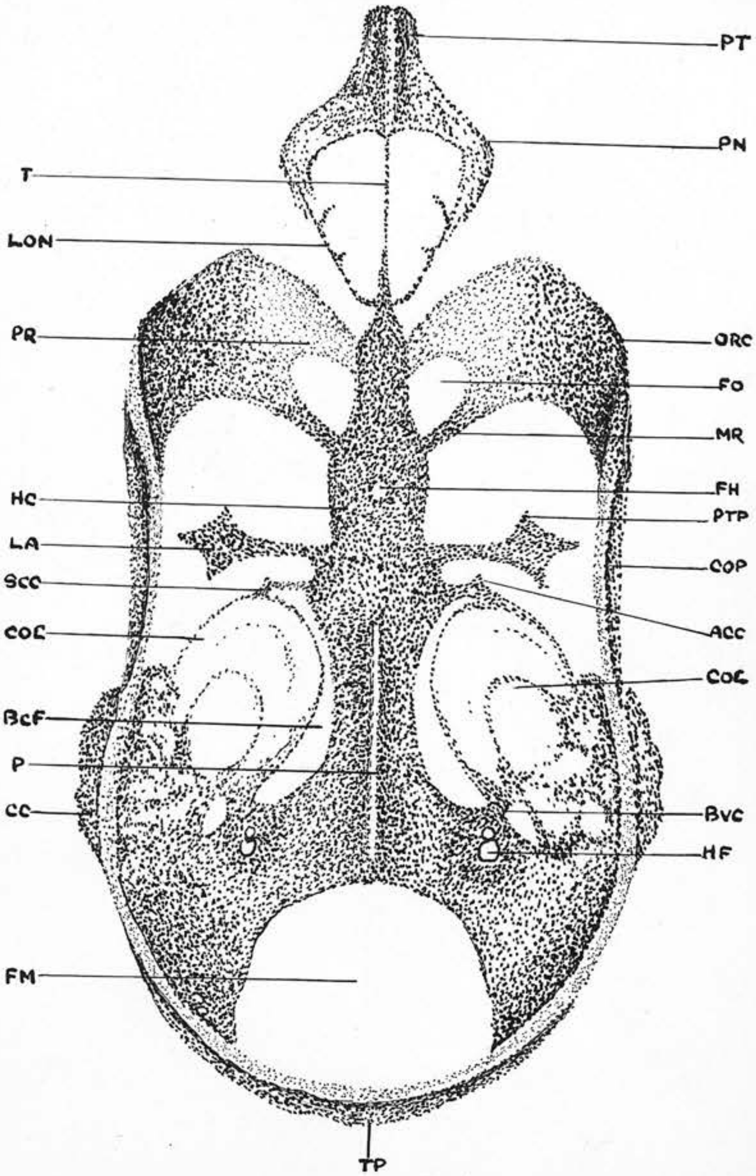

Fig. XXI Stage IX

A 1 - 28 mm. C.R.L. Dorsal View

Fig. XXII

Stage IX

A 1 - 28 mm. C.R.L.

Lateral View

CC - Canalicular part of auditory capsule.

COP - Orbito-parietal commissure.

FJ - Foramen jugulare.

FO - Optic foramen.

FOI - Fissura occipito-capsularis inferior.

FOS - Fissura occipito-capsularis superior.

I - Incus.

LH - Laterohyal.

MC - Meckel's cartilage.

MR - Metoptic root of orbital cartilage.

OA - Occipital arch.

ORC - Orbital cartilage.

PCP - Paracondylar process.

PN - Paranasal cartilage.

PPL - Parietal plate.

PT - Parietotectal cartilage.

SH - Stylohyal cartilage.

SOC - Supraoccipital cartilage.

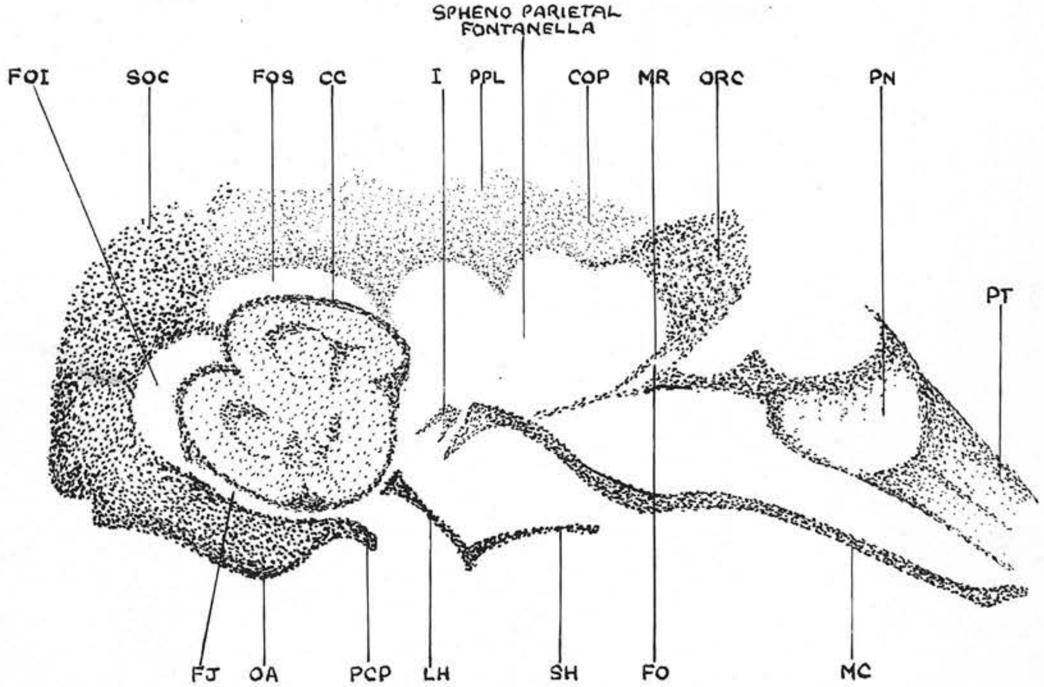

Fig. XXII Stage IX

A 1 - 28 mm. C.R.L.

Lateral View

Fig. XXIII

Stage X

A 1 - 28 mm. C.R.L.

Dorsal View of the Ala Temporalis Region.

ACC - Alicochlear commissure.

BCF - Basicochlear fissure.

BVC - Basivestibular commissure.

COC - Cochlear part of auditory capsule.

FC - Carotid foramen.

HC - Hypophyseal cartilage.

LA - Lamina ascendens.

PTP - Pterygoid process.

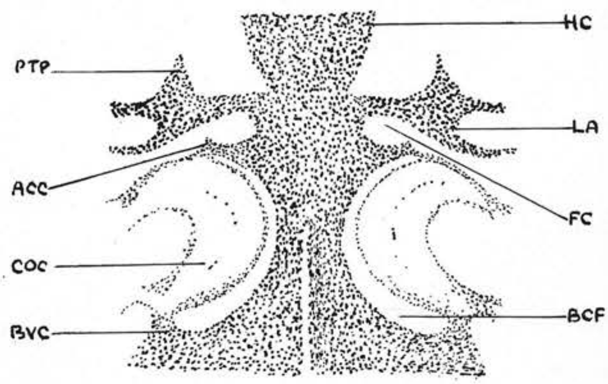

Fig. XXIII

Stage IX

A 1 - 28 mm. C.R.L.

Dorsal View of the
Ala temporalis region.

Fig. XXIV

Stage IX

A 1 - 28 mm. C.R.L.

Ventral View of the Nasal Septum

NS - Nasal septum.

PS - Paraseptal cartilage.

Fig. XXV

Stage IX

A 1 - 28 mm. C.R.L.

Lateral View of the Nasal Capsule

NS - Nasal septum.

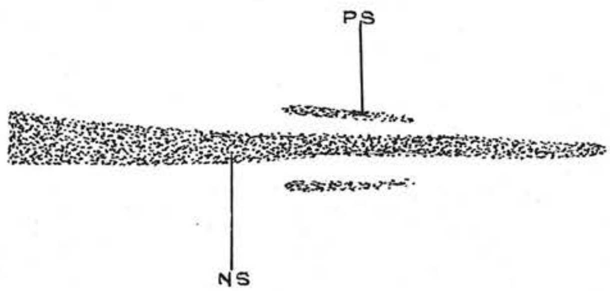

Fig. XXIV

Stage IX

A 1 - 28 mm. C.R.L.

Ventral View of the Nasal Septum

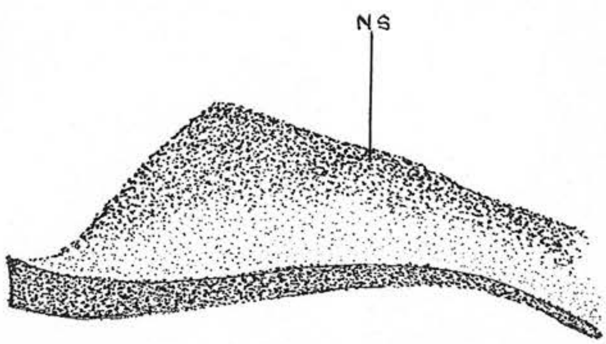

Fig. XXV

Stage IX

A 1 - 28 mm. C.R.L.

Lateral View of the Nasal Septum

Fig. XXVI

Stage IX

A 1 - 28 mm. C.R.L.

Dorsal View of the Ethmoid Region

CSE - Sphenethmoid commissure.

FE - Foramen epiphaniale.

LON - Lamina orbito-nasalis.

NS - Nasal septum.

PN - Paranasal cartilage.

PT - Parietotectal cartilage.

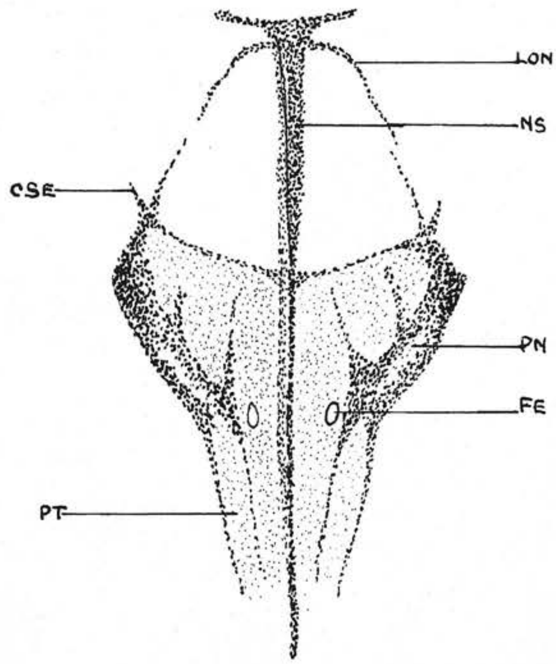

Fig. XXVI Stage IX

A 1 - 28 mm. C.R.L.

Dorsal View of the Ethmoid Region

Fig. XXVII

Stage IX

A 1 - 28 mm. C.R.L.

Lateral View of the Nasal Capsule.

PN - Paranasal cartilage.

PT - Parietotectal cartilage.

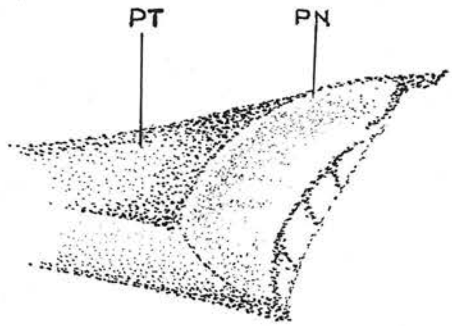

Fig. XXVII Stage IX

A 1 - 28 mm. C.R.L.

Lateral View of the Nasal Capsule

Fig. XXVIII

Stage IX

A 1 - 28 mm. C.R.L.

Medial View of the Lateral Wall
of the Ethmoid Region

CS - Crista semicircularis.

ET - Ethmoturbinal.

LON - Lamina orbito-nasalis.

MT - Maxillo-turbinal.

NT - Nasoturbinal.

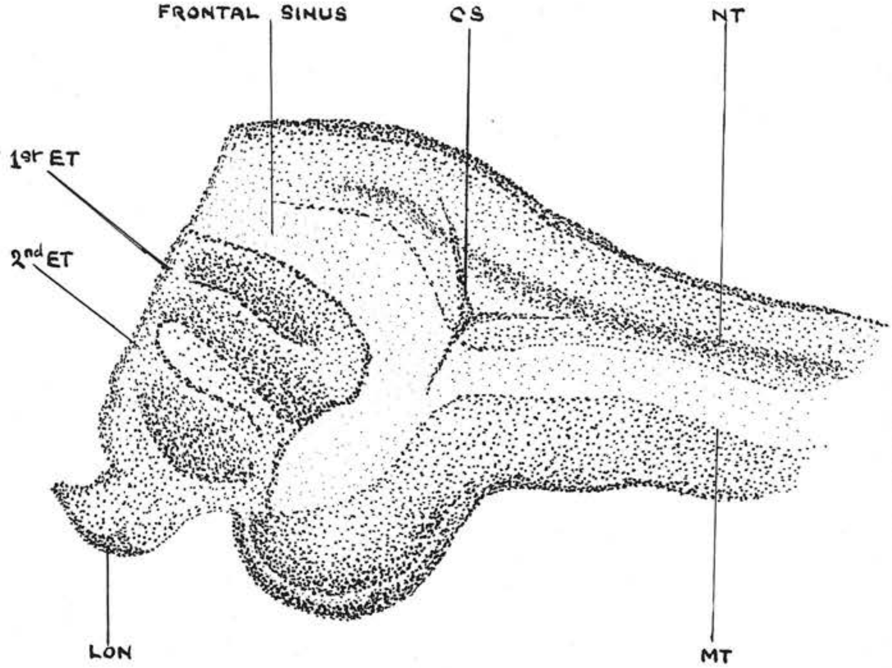

Fig. XXVIII <u>Stage IX</u>

A 1 - 28 mm. C.R.L.

Medial View of the Lateral Wall of the Ethmoid Region.

Fig. XXIX

Stage IX

A 1 - 28 mm. C.R.L.

Ventral View of the Ethmoid Region

CSE - Sphenethmoid commissure.

LON - Lamina orbito-nasalis.

NS - Nasal septum.

PN - Paranasal cartilage.

PS - Paraseptal cartilage.

PT - Parietotectal cartilage.

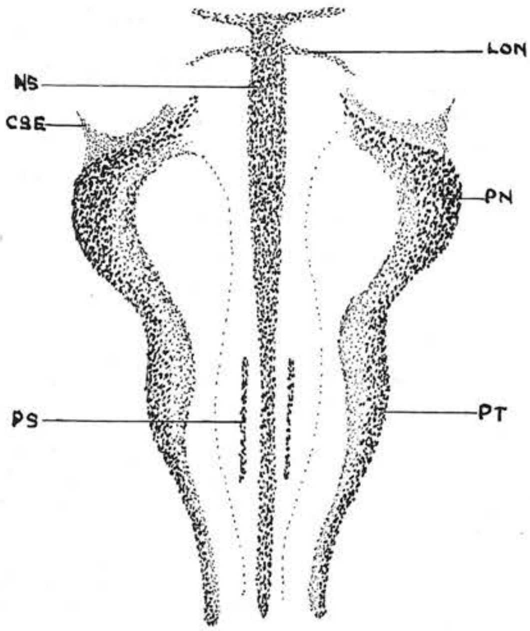

Fig. XXIX Stage IX

A 1 - 28 mm. C.R.L.

Ventral View of the Ethmoid Region

Fig. XXX

Stage IX

A 1 - 28 mm. C.R.L.

Ventral View. Splanchnoskeleton

BH - Basihyal cartilage.

CRC - Cricoid cartilage.

HH - Hypohyal cartilage.

LH - Laterohyal cartilage.

MC - Meckel's cartilage.

SH - Stylohyal cartilage.

TC - Thyroid cartilage.

TH - Thyrohyal cartilage.

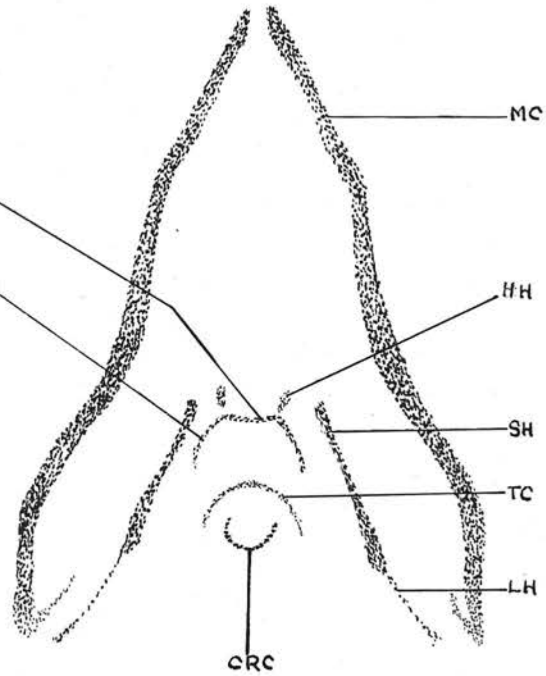

Fig. XXX Stage IX

A 1 - 28 mm. C.R.L.

Ventral View. Splanchnoskeleton.

Fig. XXXI

Stage X

C 2 - 28 mm. C.R.L.

Dorsal View

ACC - Alicochlear commissure.

AT - Ala temporalis.

BCF - Basicochlear fissure.

BVC - Basivestibular commissure.

COC - Cochlear part of auditory capsule.

FC - Carotid foramen.

FJ - Foramen jugulare.

HC - Hypophyseal cartilage.

HF - Hypoglossal foramen.

N - Notochord.

P - Parachordal or basal plate.

PTP - Pterygoid process.

SCC - Sphenocochlear commissure.

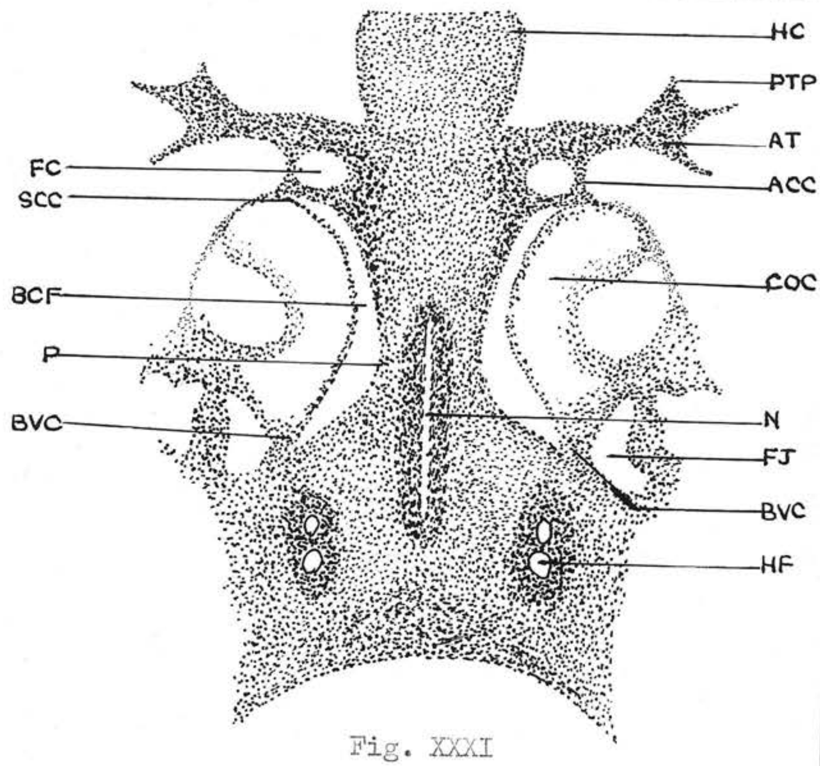

Fig. XXXI

Stage X

C 2 - 28 mm. C.R.L.

Dorsal view

Fig. XXXII

Stage X

C 2 - 28 mm. C.R.L.

Lateral View of the Optic Region only

AH - Ala hypochiasmatica.

FO - Optic foramen.

HC - Hypophyseal cartilage.

MR - Metoptic root of orbital cartilage.

ORC - Orbital cartilage.

PR - Preoptic root of orbital cartilage.

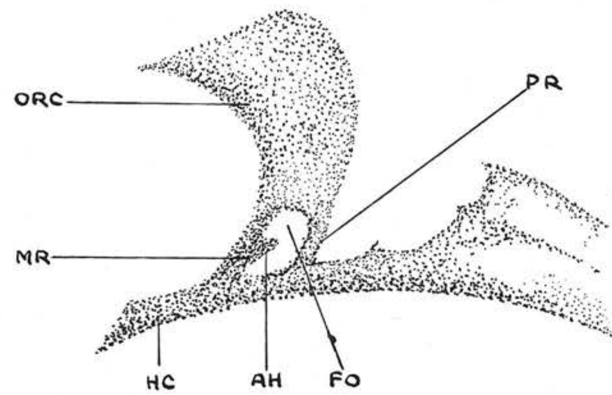

Fig. XXXII
Stage X C2 - 28 mm. C.R.L.
Lateral view of the optic region only.

Fig. XXXIII

Stage X

C 2 - 28 mm. C.R.L.

Lateral View of the Otic Region

CRP - Crista parotica.

FJ - Foramen jugulare.

FOI - Fissura occipito-capsularis inferior.

FOS - Fissura occipito-capsularis superior.

I - Incus.

MC - Meckel's cartilage.

OA - Occipital arch.

PCP - Paracondylar process.

PPL - Parietal plate.

S - Stapes.

SOC - Supraoccipital cartilage.

TTY - Tegmen tympani.

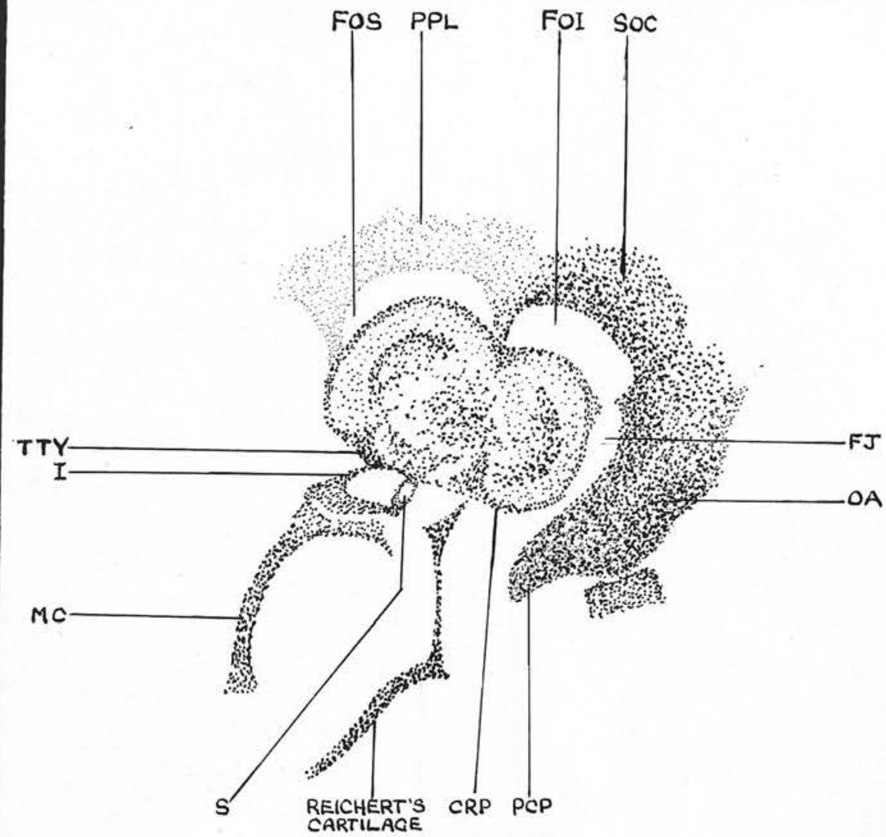

Fig. XXXIII <u>Stage X</u>

C 2 - 28 mm. C.R.L.

Lateral View of the Otic Region.

Fig. XXXIV

Stage X

C 2 - 28 mm. C.R.L.

Medial View of the Auditory Region

AT - Ala temporalis.

BCF - Basicochlear fissure.

FAC - Foramen acusticum.

FC - Carotid foramen.

FEN - Foramen endolymphaticum.

FF - Foramen for facial nerve.

FJ - Foramen jugulare.

HF - Hypoglossal foramen.

OA - Occipital arch.

P - Parachordal or basal plate.

PFC - Prefacial commissure.

PTP - Pterygoid process.

SOC - Supraoccipital cartilage.

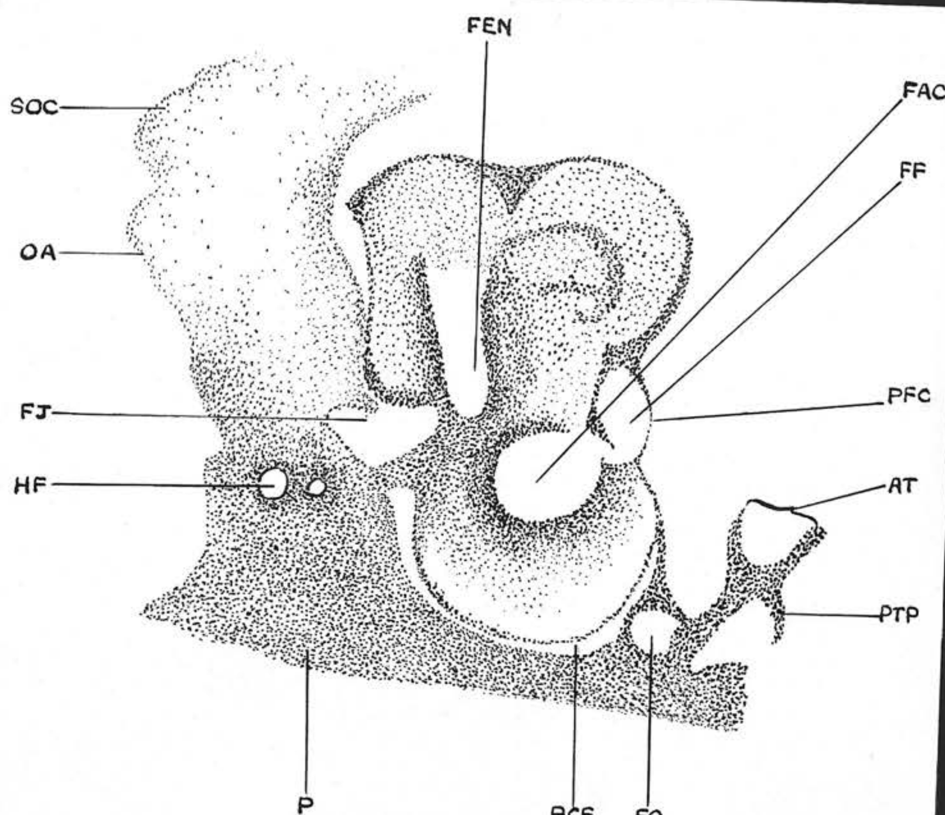

Fig.XXXIV Stage X C 2 - 28 mm. C.R.L.

Medial View of the Auditory Region

Fig. XXXVI

Stage XI

G 13 - 15 mm. H.H.

Longitudinal Section of the Central Stem
showing the Course of the Notochord

N - Notochord.

NS - Nasal septum.

P - Parachordal or basal plate.

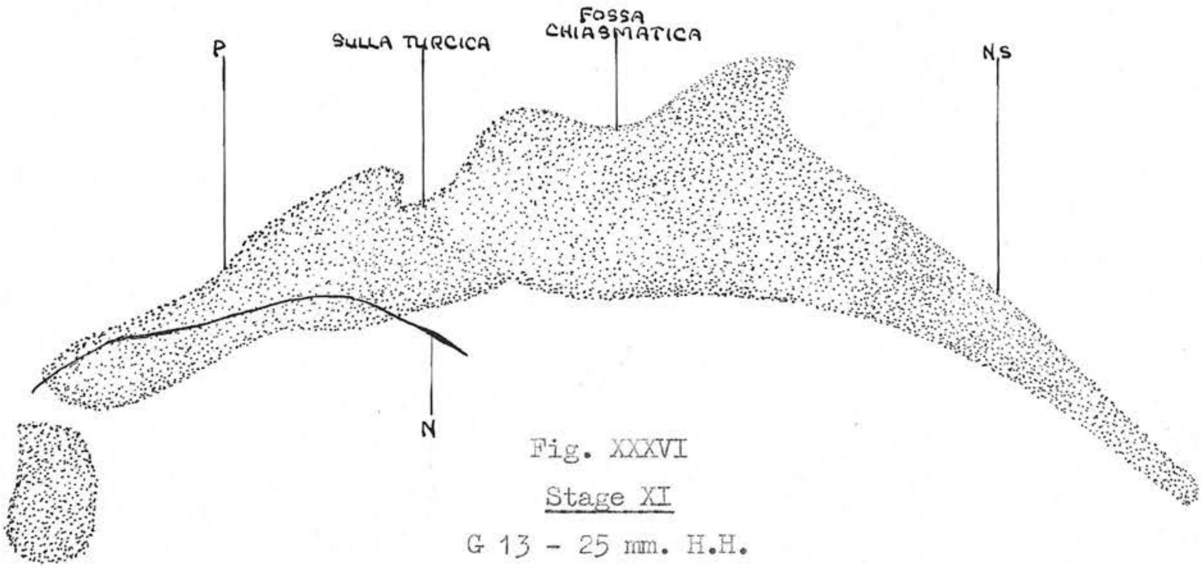

Fig. XXXVI

Stage XI

G 13 - 25 mm. H.H.

Longitudinal section of the central stem
showing the course of the notochord

Fig. XXXVII

Stage XI

G 20 - 24 mm. H.H.

Dorsal View of Hypophyseal Cartilage
showing the Posterior Limit and the Crista Transversa

BCF - Basicochlear fissure.

COC - Cochlear part of auditory capsule.

CT - Crista transversa.

FC - Carotid foramen.

HC - Hypophyseal cartilage.

P - Parachordal or basal plate.

PTP - Pterygoid process.

SCC - Sphenocochlear commissure.

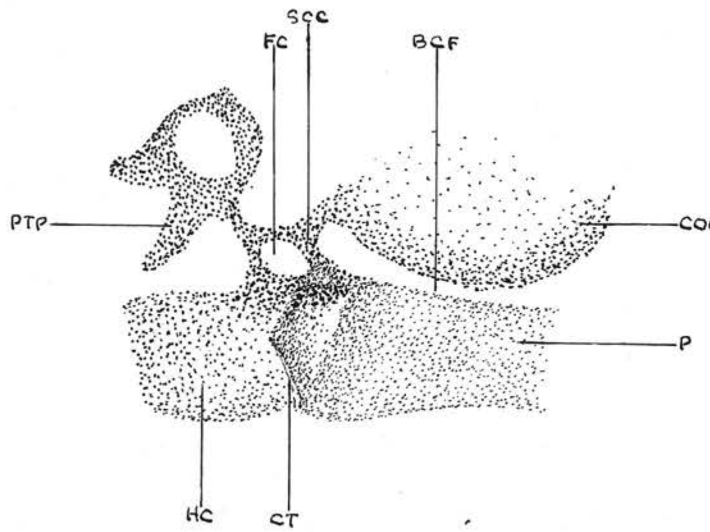

Fig. XXXVII

Stage XI G 20 - 24 mm. H.H.

Dorsal view of hypophyseal cartilage showing the posterior limit and the crista transversa.

Fig. XXXVIII

Stage XI

G 13 - 25 mm. H.H.

Dorsal View of the Interorbito-nasal Cartilage

AH - Ala hypochiasmatica.

FO - Optic foramen.

HC - Hypophyseal cartilage.

IOS - Interorbital septum.

LON - Lamina orbito-nasalis.

MR - Metoptic root of orbital cartilage.

NS - Nasal septum.

PR - Preoptic root of orbital cartilage.

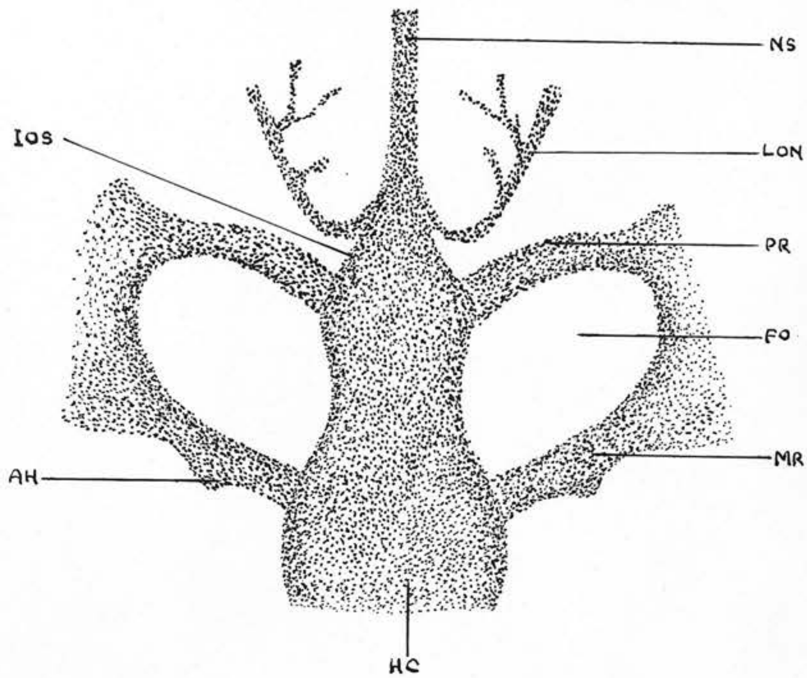

Fig. XXXVIII

Stage XI

G 13 - 25 mm. H.H.

Dorsal View of the Interorbito-
nasal cartilage.

Fig. XXXIX

Stage XI

G 20 - 24 mm. H.H.

Nasal Septum

CRG - Crista galli.

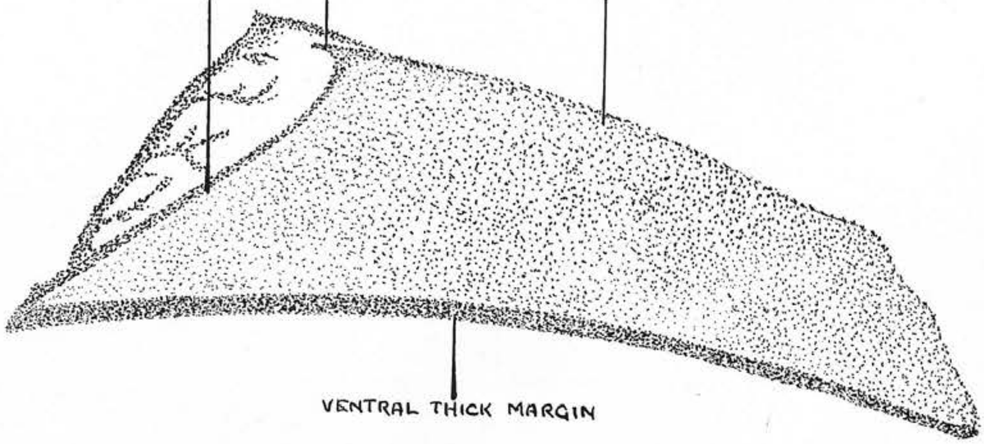

Fig. XXXIX

Stage XI

G 20 - 24 mm. H.H.

Nasal septum

Fig. XL

Stage XI

G 6 - 19 mm. H.H.

Dorsal View of the Subcerebral Part of the Nasal Septum

IOS - Interorbital septum.

LON - Lamina orbito-nasalis.

NS - Nasal septum.

PT - Parietotectal cartilage.

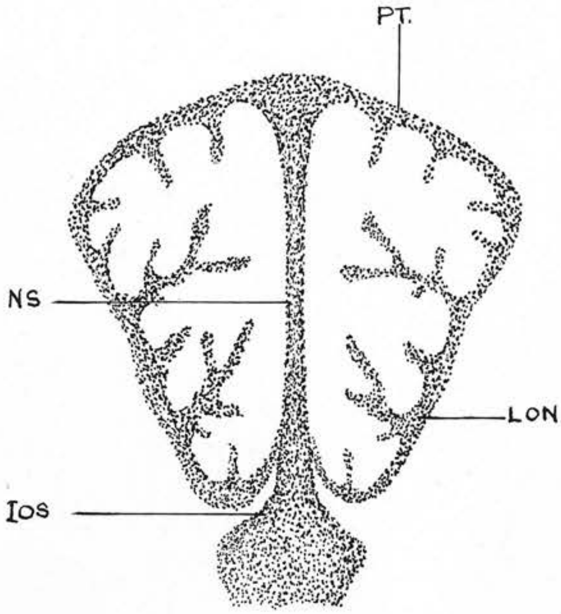

Fig. XL

Stage XI

G 6 - 19 mm. H.H.

Dorsal view of the subcerebral part of the nasal septum.

Fig. XLI

Stage XI

G 13 - 25 mm. H.H.

Lateral View of the Otic Region

CC - Canalicular part of auditory capsule.

COC - Cochlear part of auditory capsule.

CRP - Crista parotica.

FM - Foramen magnum.

FP - Foramen perilymphaticum.

OC - Occipital condyle.

PCP - Paracondylar process.

PPL - Parietal plate.

SH - Stylohyal cartilage.

SOC - Supraoccipital cartilage.

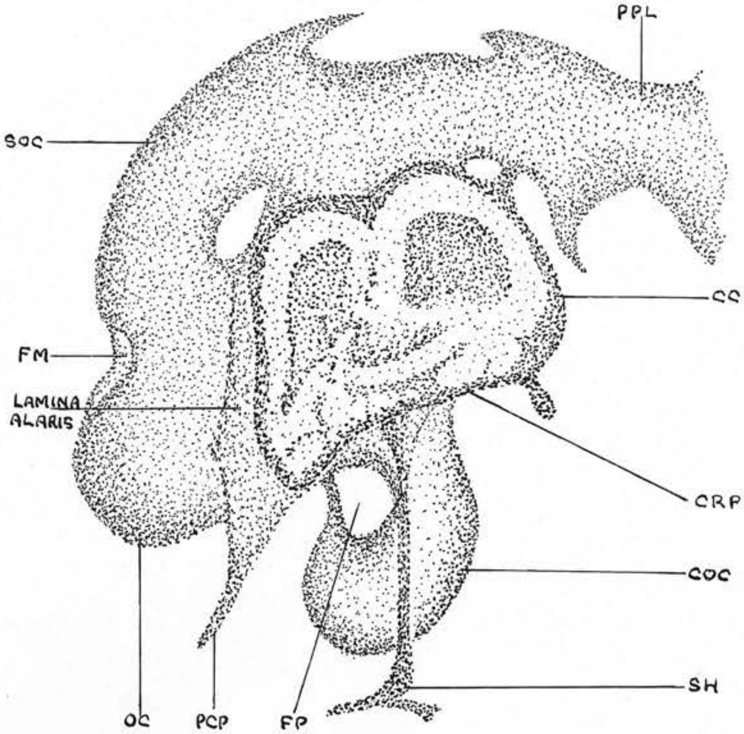

Fig. XLI. Stage XI G 13 - 25 m.m. H.H.

Lateral view of the otic region.

Fig. XLII

Stage XI

G 13 - 25 mm. H.H.

Medial View of the Otic Region

AT - Ala temporalis.

BCF - Basicochlear fissure.

BVC - Basivestibular commissure.

CC - Canalicular part of auditory capsule.

FC - Carotid foramen.

FEN - Foramen endolymphaticum.

FF - Foramen for facial nerve.

FJ - Foramen jugulare.

FOI - Fissura occipito-capsularis inferior.

FOS - Fissura occipito-capsularis superior.

FP - Foramen perilymphaticum.

P - Parachordal or basal plate.

PFC - Prefacial commissure.

PRR - Processus recessus.

PTP - Pterygoid process.

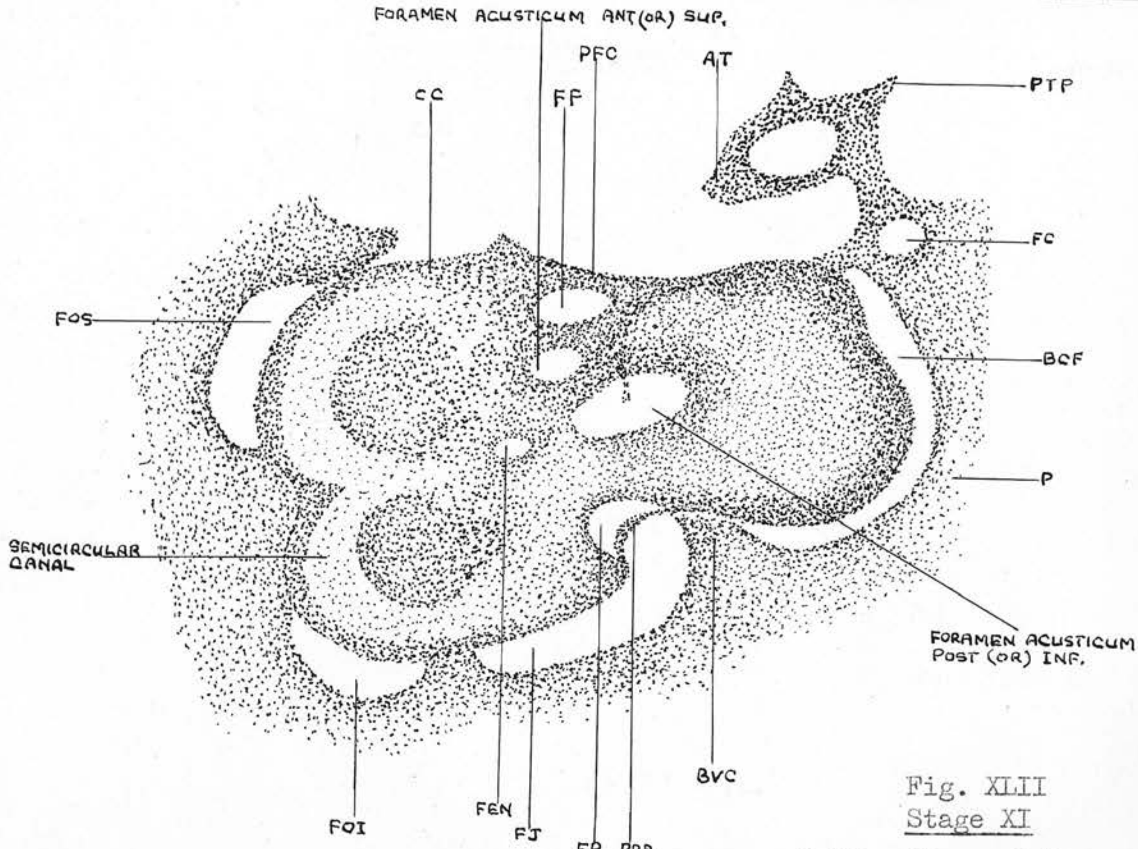

Fig. XLII
Stage XI

G 13 - 25m.m. H.H.

Medial view of the otic region.

Fig. XLIII

Stage XI

G 13 - 25 mm. H.H.

Posterior View of the Occipital Arch

FM - Foramen magnum.

PCP - Paracondylar process.

SOC - Supraoccipital arch.

TP - Tectum posterius.

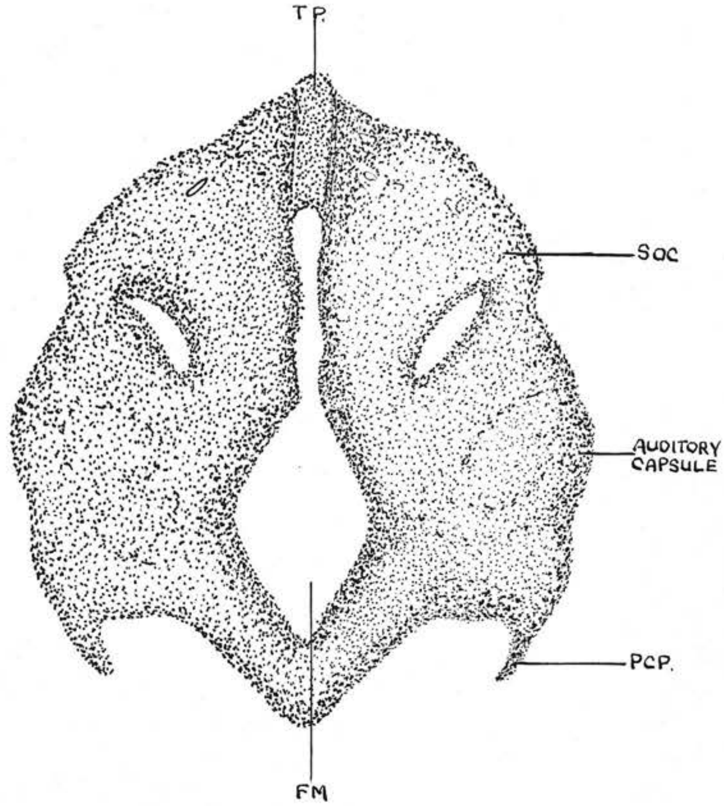

Fig. XLIII

Stage XI

G 13 - 25 mm. H.H.

Posterior view of the occipital arch.

Fig. XLIV

Stage XI

G 20 - 24 mm. H.H.

Lateral View of the Canalicular Capsule

COC - Cochlear part of auditory capsule.

FOI - Fissura occipito-capsularis inferior.

FOS - Fissura occipito-capsularis superior.

MP - Mastoid process.

OA - Occipital arch.

PCP - Paracondylar process.

SH - Stylohyal.

TTY - Tegmen tympani.

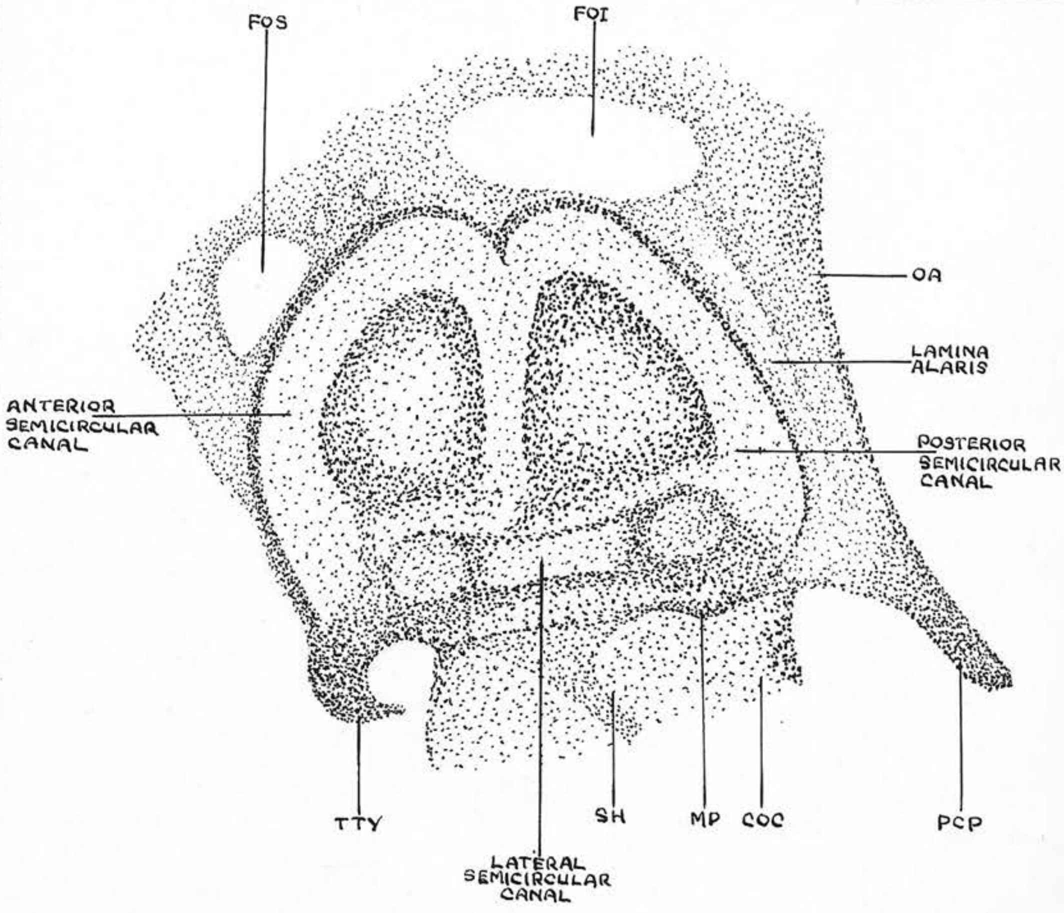

Fig. XLIV

Stage XI

G 20 - 24 mm. H.H.

Lateral View of the Canalicular Capsule

Fig. XLV

Stage XI

G 20 - 24 mm. H.H.

Medial View of the Canalicular Capsule

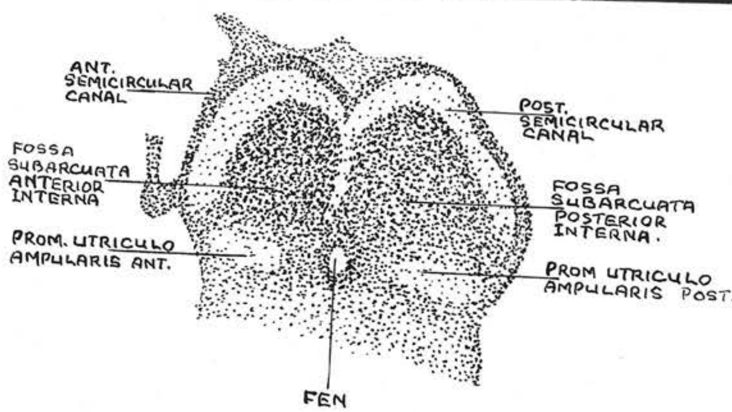

Fig. XLV Stage XI
G 20 - 24 mm. H.H.
Medial View of the Canalicular Capsule.

Fig. XLVI

Stage XI

G 20 - 24 mm. H.H.

Lateral View of the Cochlear Capsule

CC - Canalicular part of auditory capsule.

COC - Cochlear part of auditory capsule.

FOV - Fenestra ovalis.

FP - Foramen perilymphaticum.

PFC - Prefacial commissure.

PRR - Processus recessus.

S - Stapes.

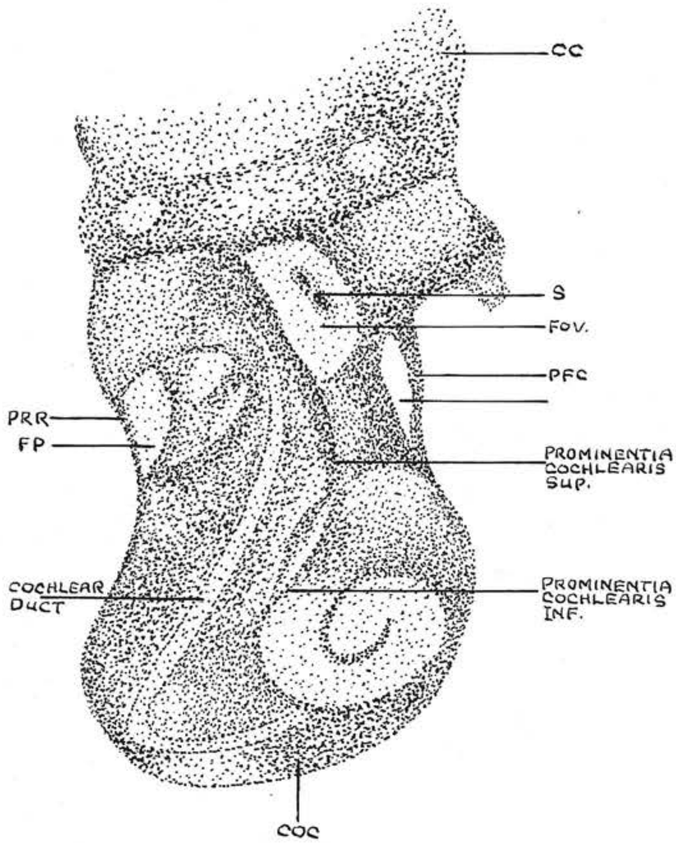

Fig. XLVI

Stage XI   G 20 - 24 mm. H.H.

Lateral View of the Cochlear Capsule.

Fig. XLVII

Stage XI

G 20 - 24 mm. H.H.

Medial View of the Auditory Capsule

BCF - Basicochlear fissure.

BVC - Basivestibular commissure.

FEN - Foramen endolymphaticum.

FF - Foramen for facial nerve.

FJ - Foramen jugulare.

FOI - Fissura occipito-capsularis inferior.

FOS - Fissura occipito-capsularis superior.

FP - Foramen perilymphaticum.

P - Parachordal or basal plate.

PFC - Prefacial commissure.

PPL - Parietal plate.

PRR - Processus recessus.

PTP - Pterygoid process.

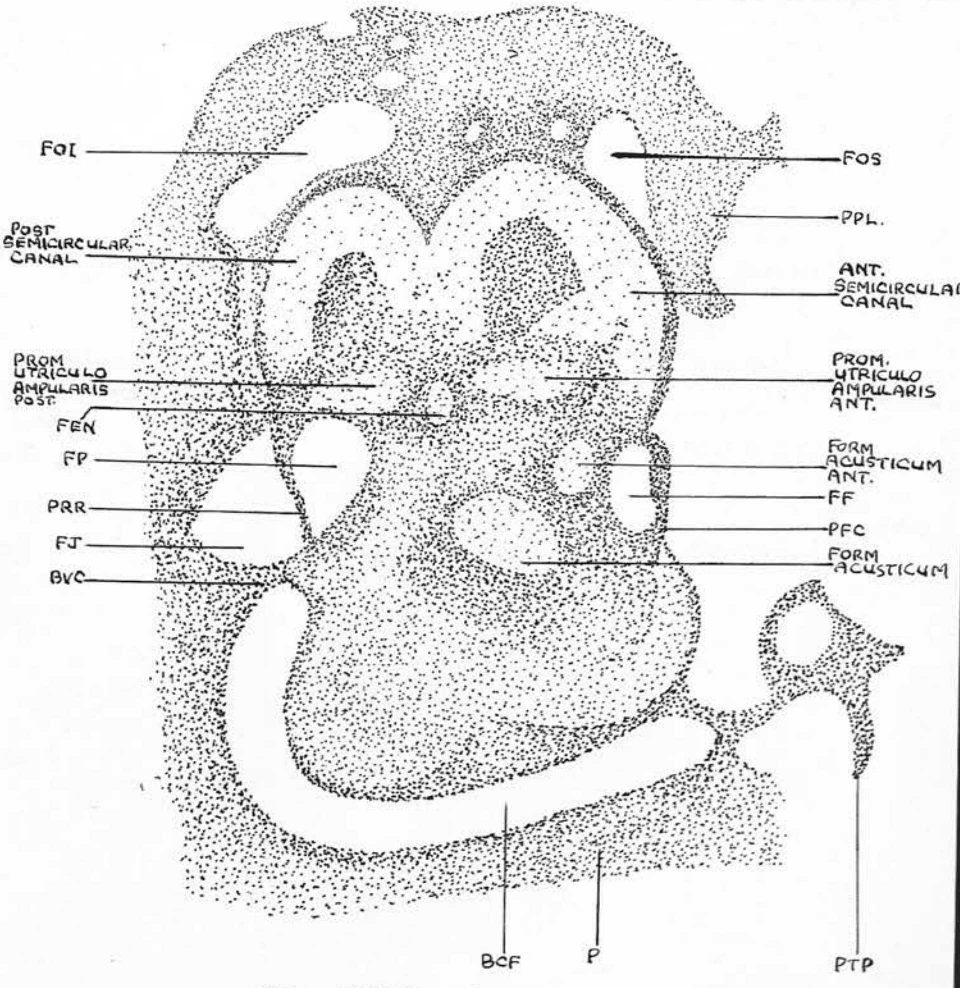

Fig. XLVII Stage XI

G 20 - 24 mm. H.H.

Medial View of the Auditory Capsule.

Plate XLVIII

Stage XI

G 20 - 24 mm. H.H.

Medial View of the Auditory Capsule

FACI - Foramen acusticum inferior.

FACS - Foramen acusticum superior.

FF - Foramen for facial nerve.

FJ - Foramen jugulare.

FOI - Fissura occipito-capsularis inferior.

FOS - Fissura occipito-capsularis superior.

FR - Foramen rotundum.

HF - Hypoglossal foramen.

MC - Meckel's cartilage.

ORC - Orbital cartilage.

PCC - Parieto-capsular commissure.

PFC - Prefacial commissure.

PRR - Processus recessus.

PTP - Pterygoid process.

S - Stapes.

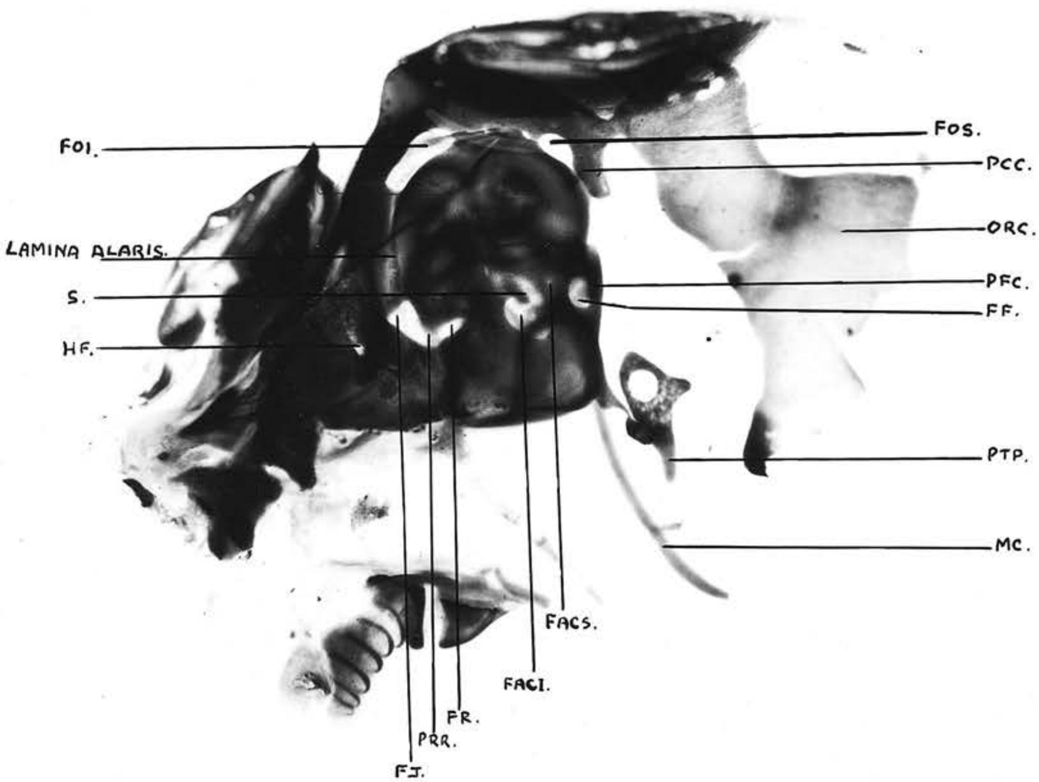

PLATE XLVIII, STAGE XI.
♀ 20 - 24 mm. H. H.
MEDIAL VIEW OF THE
AUDITORY CAPSULE.

Plate XLIX

Stage XI

G 6 - 19 mm. H.H.

Lateral View of the Auditory Capsule.

CSE - Sphenethmoid commissure.

FJ - Foramen jugulare.

FO - Optic foramen.

FOI - Fissura occipito-capsularis inferior.

FOS - Fissura occipito-capsularis superior.

FOV - Fenestra ovalis.

FR - Foramen rotundum.

MC - Meckel's cartilage.

MR - Metoptic root of orbital cartilage.

NC - Nasal capsule.

ONF - Orbito-nasal fissure.

PR - Preoptic root of orbtial cartilage.

S - Stapes.

SOC - Supraoccipital cartilage.

SPF - Sphenoparietal fontanelle.

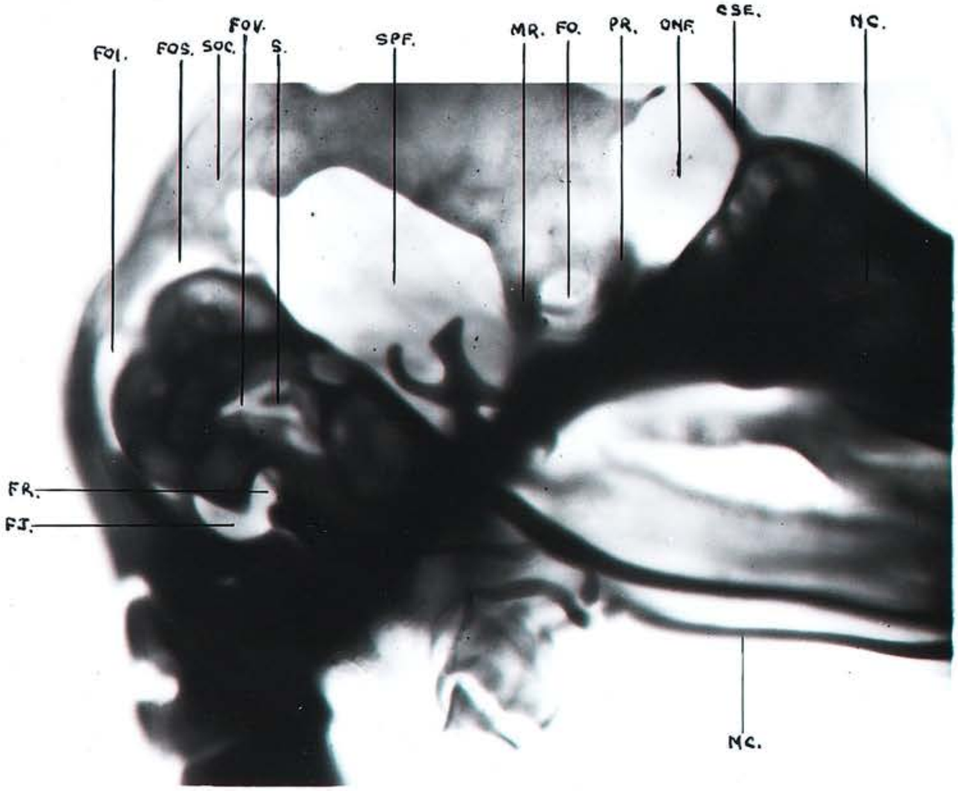

PLATE XLIX. STAGE XI
G6 – 19 mm. H.H.
LATERAL VIEW OF THE
AUDITORY CAPSULE

Plate L

Stage XI

G 20 - 24 mm. H.H.

Lateral View of the Auditory Capsule

FJ - Foramen jugulare.

FLP - Fissura lamina parietalis.

FOI - Fissura occipito-capsularis inferior.

FOS - Fissura occipito-capsularis superior.

FOV - Fenestra ovalis.

MC - Meckel's cartilage.

ORC - Orbital cartilage.

PPL - Parietal plate.

S - Stapes.

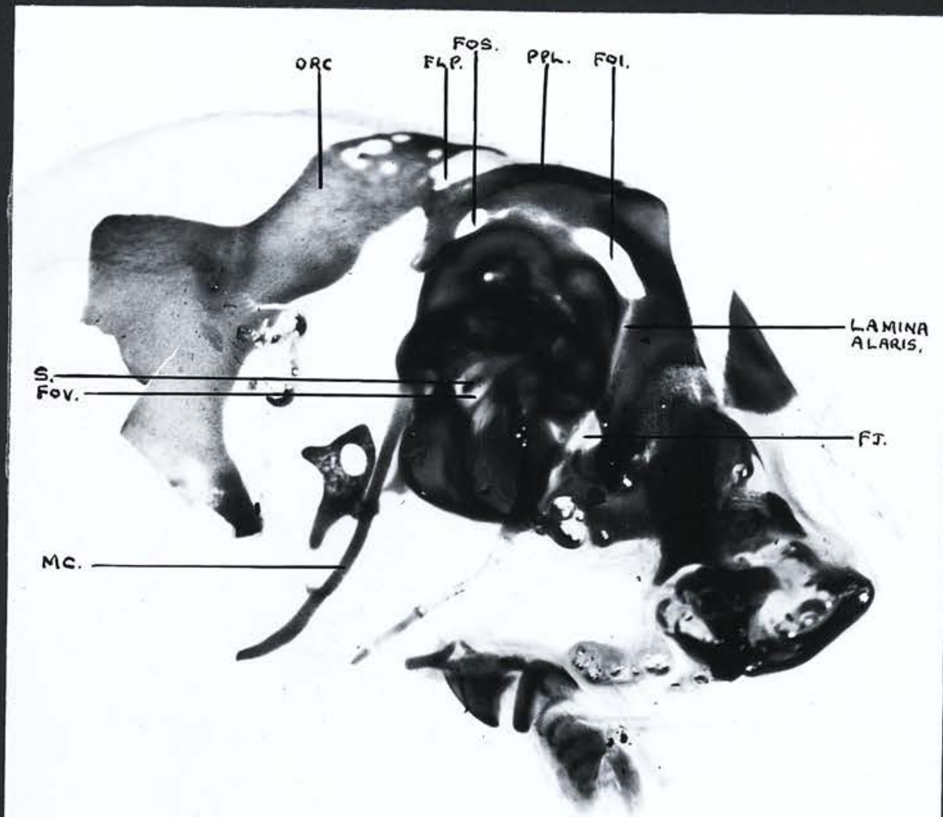

PLATE L STAGE XI.
C. 20 – 24 mm. H·H.
LATERAL VIEW OF
THE AUDITORY CAPSULE.

Plate LI

Stage XI

G 6 - 19 mm. H.H.

Lateral View

COP - Orbito-parietal commissure.

CSE - Sphenethmoid commissure.

CRC - Cricoid cartilage.

FJ - Foramen jugulare.

FO - Optic foramen.

FOI - Fissura occipito-capsularis inferior.

FOS - Fissura occipito-capsularis superior.

FR - Foramen rotundum.

MC - Meckel's cartilage.

MR - Metoptic root of orbital cartilage.

NC - Nasal capsule.

ONF - Orbito-nasal fissure.

ORC - Orbital cartilage.

PCC - Parieto-capsular commissure.

PPL - Parietal plate.

PR - Preoptic root of orbital cartilage.

S - Stapes.

SPF - Sphenoparietal fontanelle.

TC - Thyroid cartilage.

TR - Tracheal ring.

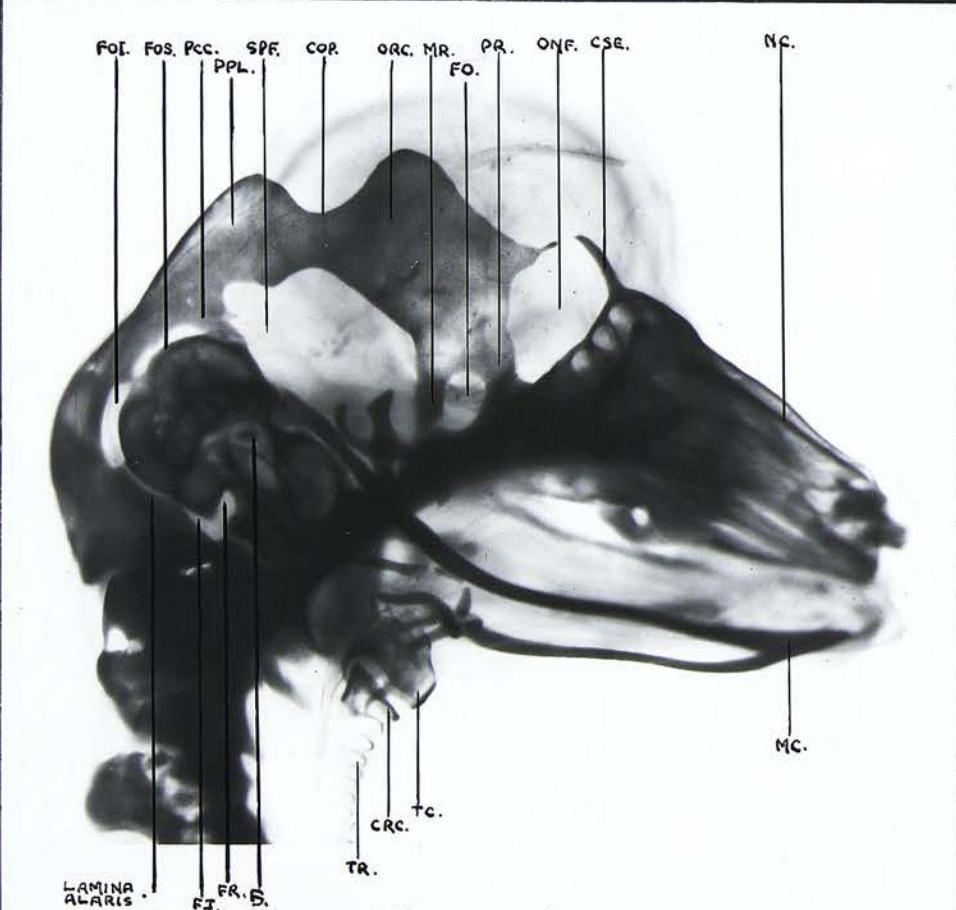

PLATE LI. STAGE XI.
G6 – 19 mm. H.H.
LATERAL VIEW.

Fig. LII

Stage XI

G 6 - 19 mm. H.H.

Lateral View of the Ala Orbitalis

AH - Ala hypochiasmatica.

COP - Orbito-parietal commissure.

FO - Optic foramen.

HC - Hypophyseal cartilage.

MR - Metoptic root of orbital cartilage.

ORC - Orbital cartilage.

PR - Preoptic root of orbital cartilage.

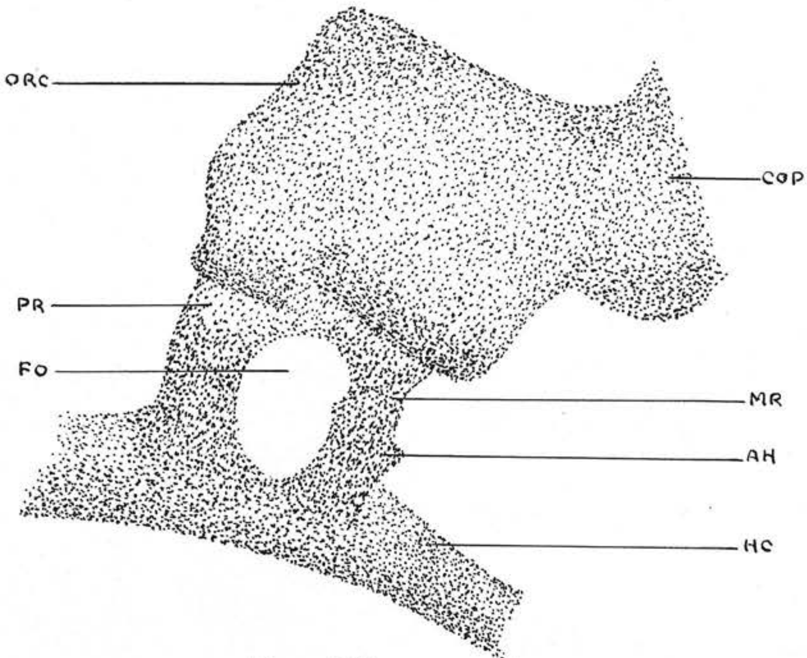

Fig. LII

Stage XI

G 6 19 mm. H.H.

Lateral view of the ala orbitalis

Fig. LIII

Stage XI

G 6 - 19 mm. H.H.

Dorsal View of the Ala Orbitalis

AH - Ala hypochiasmatica.

COP - Orbito-parietal commissure.

FO - Optic foramen.

HC - Hypophyseal cartilage.

IOS - Interorbital septum.

MR - Metoptic root of orbital cartilage.

ORC - Orbital cartilage.

PR - Preoptic root of orbital cartilage.

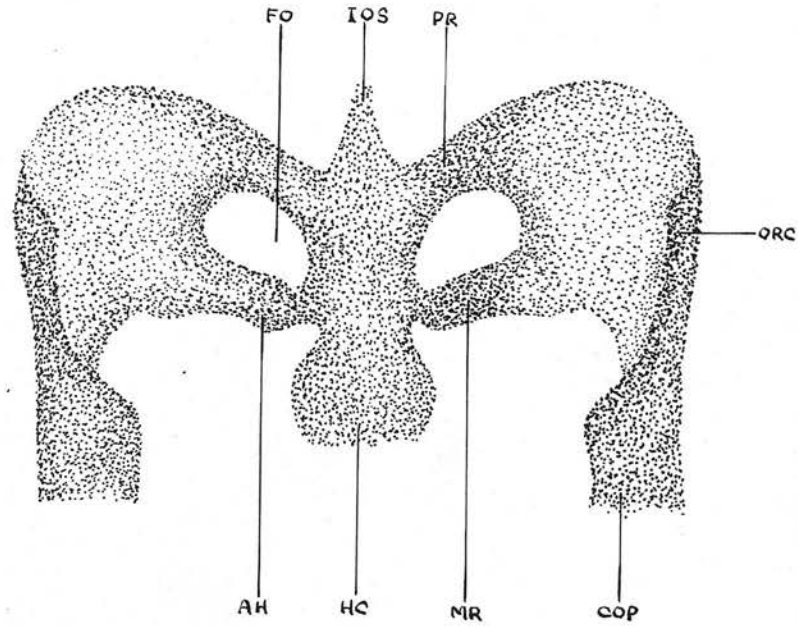

Fig. LIII

Stage XI

G 6 - 19mm. H.H.

Dorsal view of the ala orbitalis

Plate LIV

Stage XI

G 6 - 19 mm. H.H.

Lateral View

COP - Orbito-parietal commissure.

CSE - Sphenethmoid commissure.

FLP - Fissura lamina parietalis.

FO - Optic foramen.

FOI - Fissura occipito-capsularis inferior.

MC - Meckel's cartilage.

NC - Nasal capsule.

OA - Occipital arch.

ONF - Orbito-nasal fissure.

ORC - Orbital cartilage.

PPL - Parietal plate.

SH - Stylohyal cartilage.

SOC - Supraoccipital cartilage.

SPF - Sphenoparietal fontanelle.

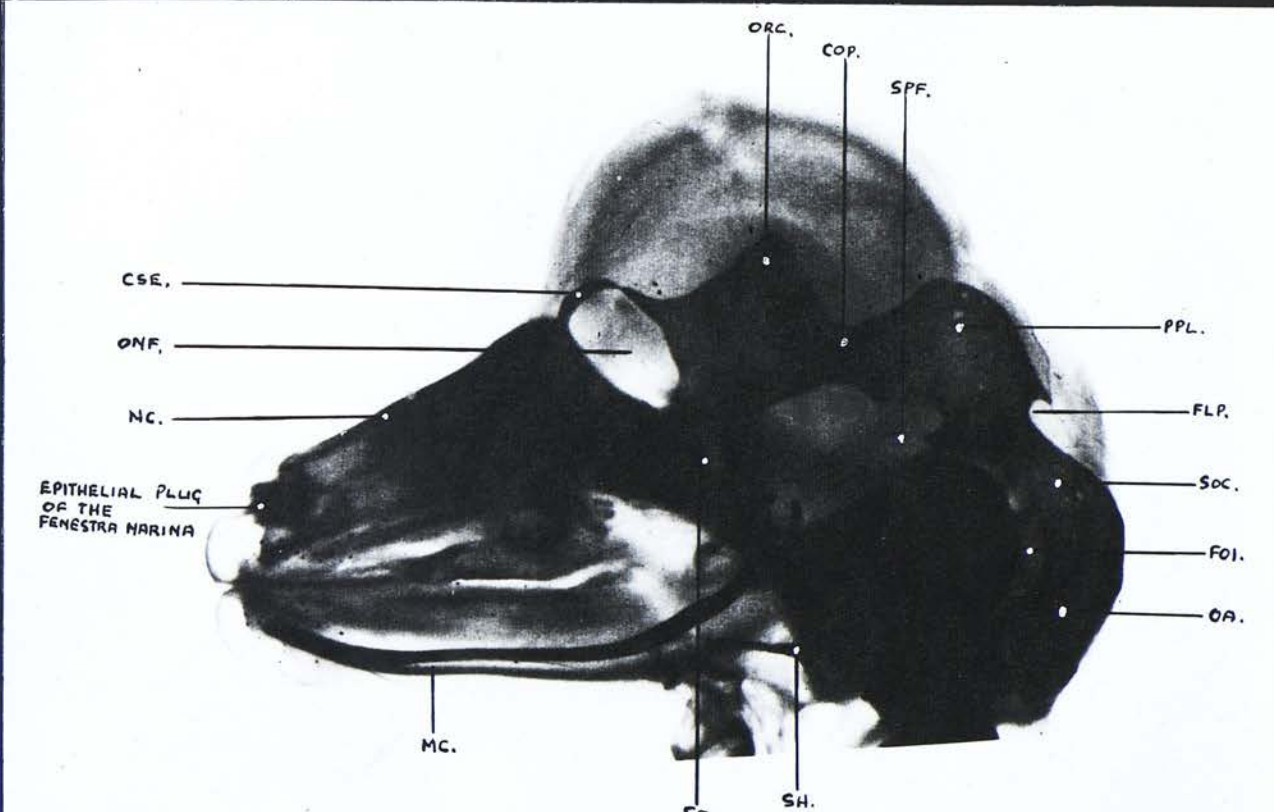

PLATE LIV STAGE XI.
G6. —19 mm. H.H.
LATERAL VIEW.

Plate LV

Stage XI

G 20 - 24 mm. H.H.

Lateral View of the Auditory Capsule

FJ - Foramen jugulare.

FLP - Fissura lamina parietalis.

FOI - Fissura occipito-capsularis inferior.

FOS - Fissura occipito-capsularis superior.

FOV - Fenestra ovalis.

MC - Meckel's cartilage.

ORC - Orbital cartilage.

PPL - Parietal plate.

S - Stapes.

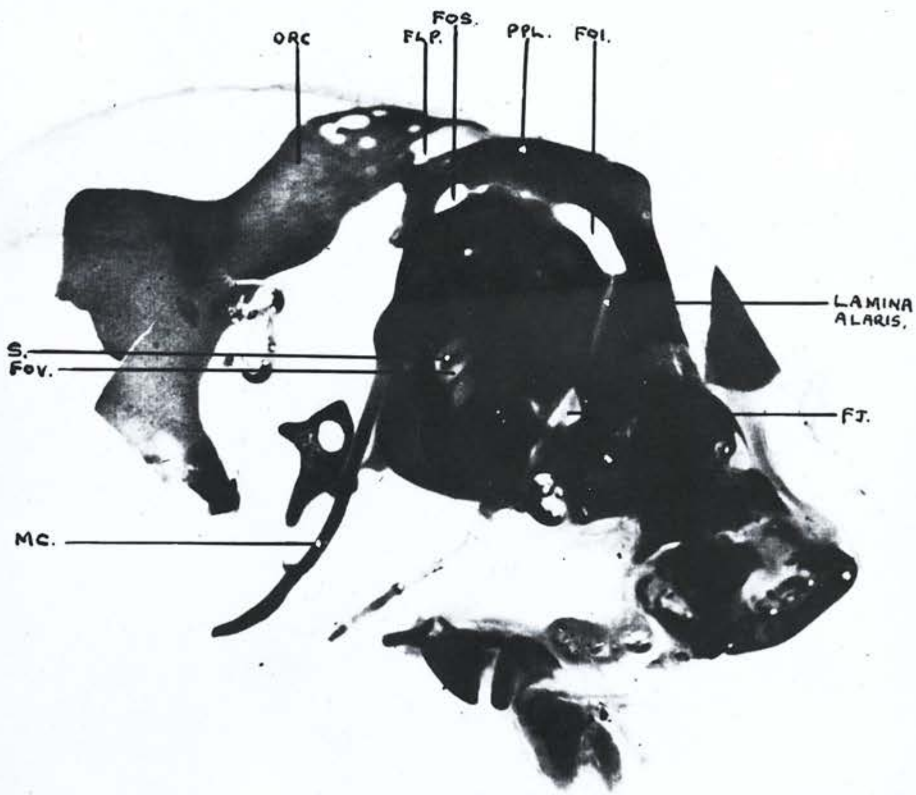

PLATE LV STAGE XI.
C.20 - 24 mm. H.H.
LATERAL VIEW OF
THE AUDITORY CAPSULE.

Fig. LVI

Stage XI

G 13 - 25 mm. H.H.

Dorsal View of the Cribriform Plate

NS - Nasal septum.

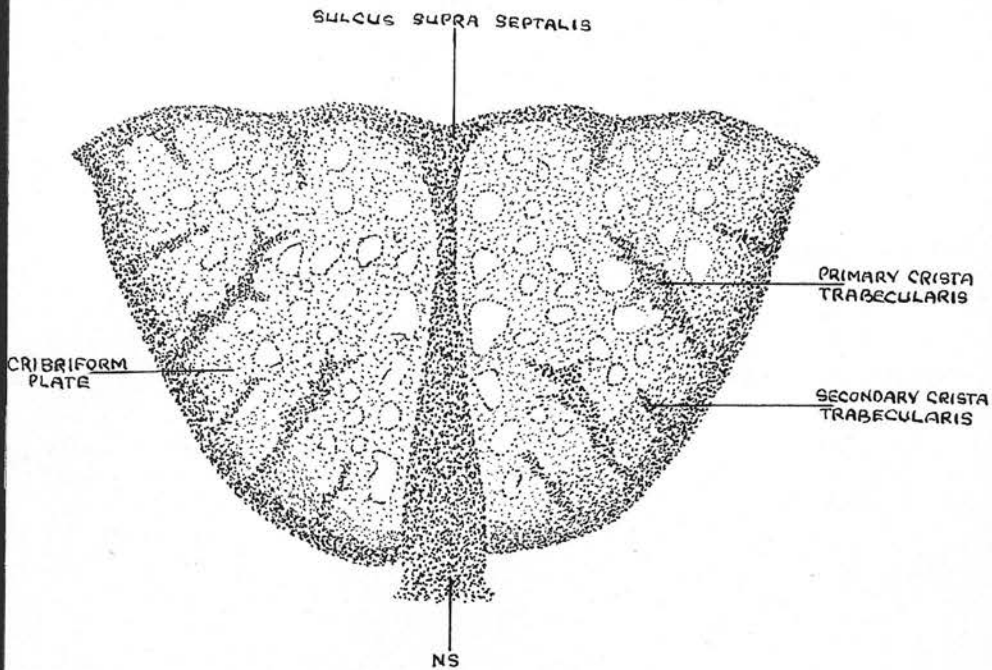

Fig. LVI

Stage XI

G 13 - 25 mm. H.H.

Dorsal View of the Cribriform Plate.

Fig. LVII

Stage XI

G 13 - 25 mm. H.H.

Dorsal View of the Nasal Capsule

CRG - Crista galli.

FE - Foramen epiphaniale.

LON - Lamina orbito-nasalis.

NS - Nasal septum.

PN - Paranasal cartilage.

PT - Parietotectal cartilage.

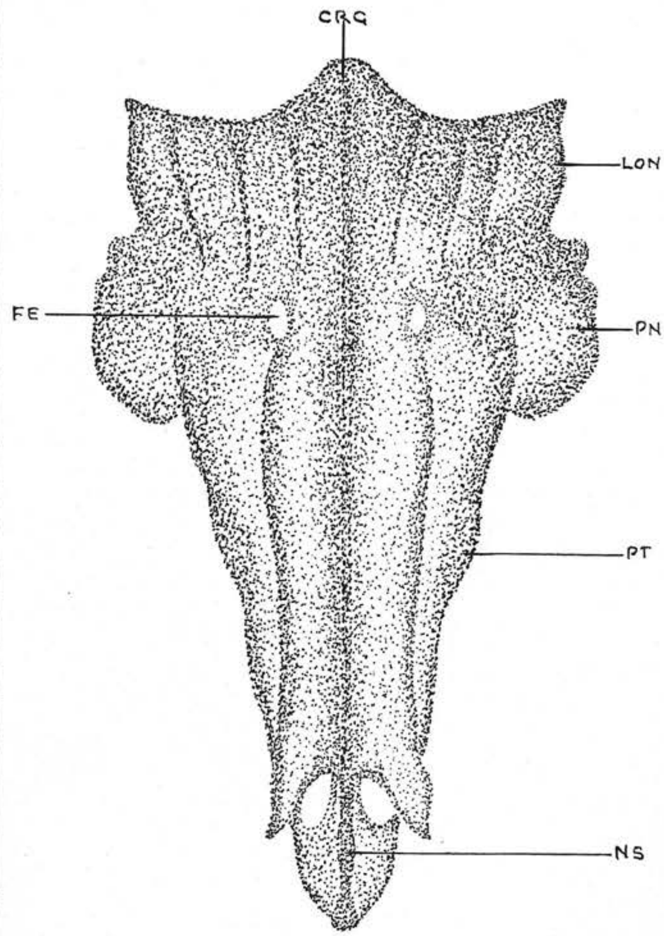

Fig. LVII

Stage XI

G 13 - 25 mm. H.H.

Dorsal View of the Nasal Capsule

Plate LVIII

Stage XI

G 13 - 25 mm. H.H.

Lateral View of the Nasal Capsule

CDN - Cartilago ductus nasopalatini.

LON - Lamina orbito-nasalis.

MT - Maxillo-turbinal.

NLD - Naso-lachrymal duct.

NT - Nasoturbinal.

PN - Paranasal cartilage.

PS - Paraseptal cartilage.

PT - Parietotectal cartilage.

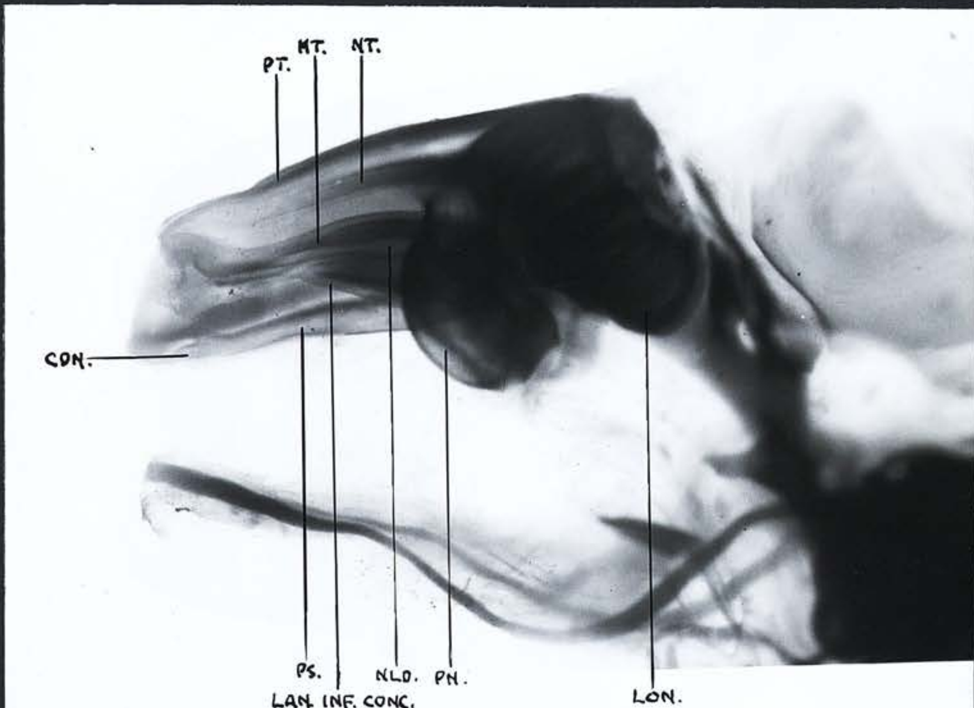

PLATE LVIII STAGE XI
G 13 - 25 mm. H.H
LATERAL VIEW OF THE
NASAL CAPSULE.

Plate LIX

Stage XI

H 5 - 37 mm. H.H.

Lateral View

CDN - Cartilago ductus nasopalatini.

INCISURA TRANS ANT - Incisura transversalis anterior.

INCISURA TRANS POST - Incisura transversalis posterior.

LAM INF CONC - Lamina inferior conchalis.

LTA - Lamina transversalis anterior.

NLD - Naso-lachrymal duct.

NS - Nasal septum.

NT - Nasoturbinal.

PAS - Processus alaris superior.

PS - Paraseptal cartilage.

PT - Parietotectal cartilage.

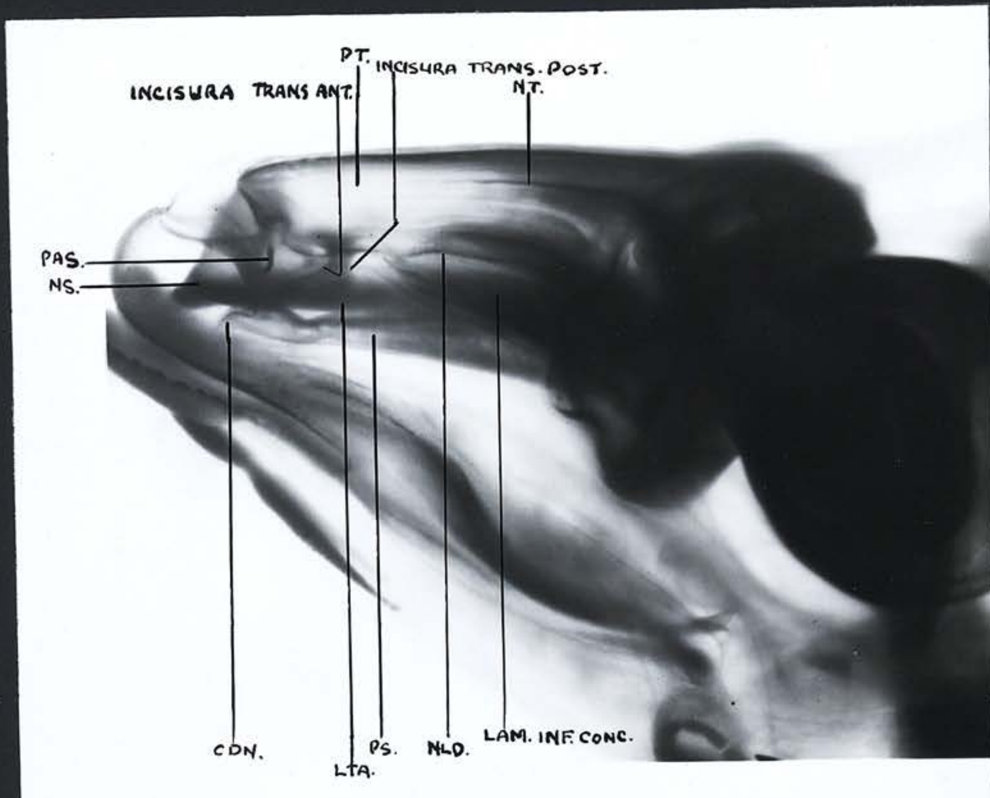

PLATE LIX. STAGE XI
H5 ~ 37 mm. H.H.
LATERAL VIEW.

Fig. LX

Stage XI

G 13 - 25 mm. H.H.

Lateral View of the Anterior Region
of the Nasal Capsule

CDN - Cartilago ductus nasopalatini.

LTA - Lamina transversalis anterior.

NS - Nasal septum.

NT - Nasoturbinal.

PAS - Processus alaris superior.

PS - Paraseptal cartilage.

PT - Parietotectal cartilage.

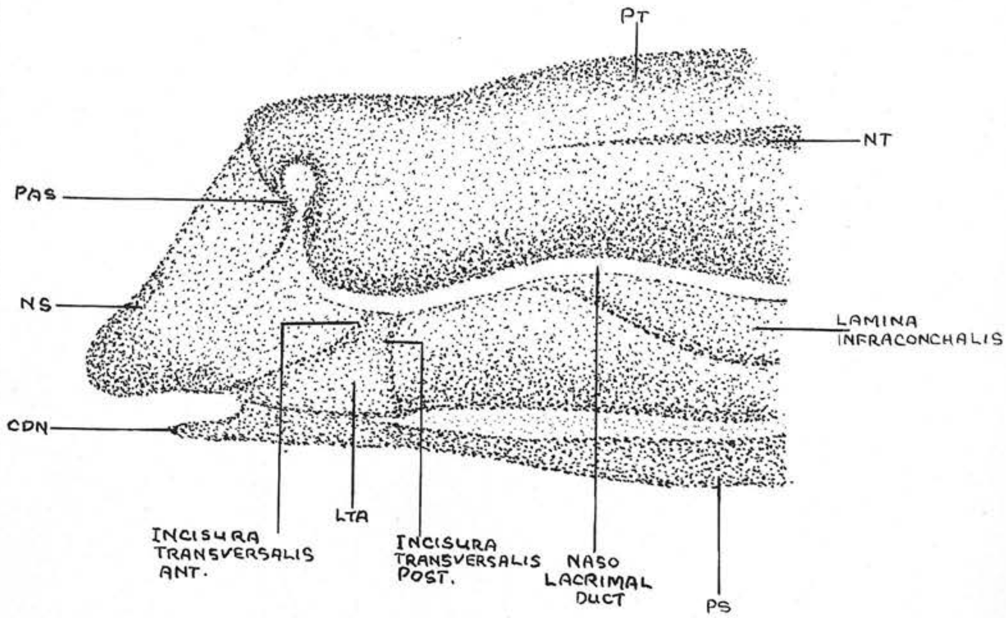

Fig. LX Stage XI

G 13 - 25 mm. H.H.

Lateral View of the Anterior Region of the Nasal Capsule.

Fig. LXI

Stage XI

G 13 - 25 mm. H.H.

Ventral View of the Anterior Region
of the Nasal Capsule

BF - Basicranial fenestra.

CDN - Cartilago ductus nasopalatini.

LTA - Lamina transversalis anterior.

NS - Nasal septum.

PT - Parietotectal cartilage.

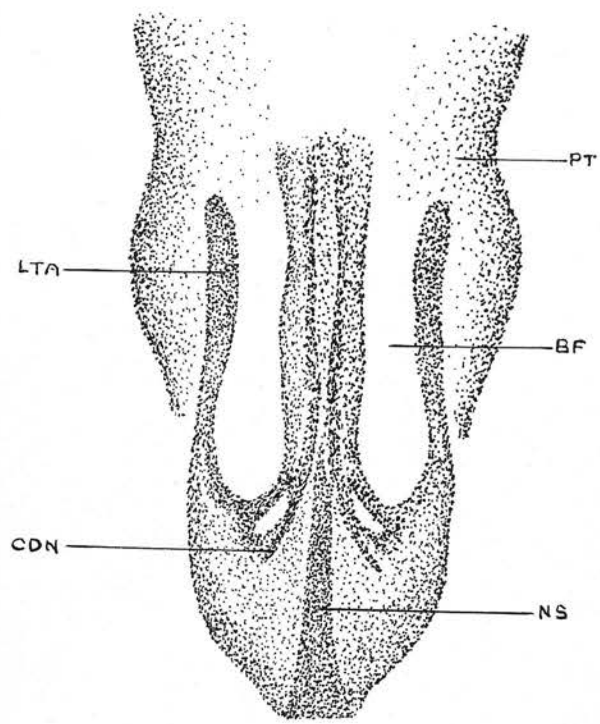

Fig. LXI

Stage XI

G 13 - 25 mm. H.H.

Ventral View of the Anterior Region of the Nasal Capsule.

Fig. LXII

Stage XI

G 13 - 25 mm. H.H.

Ventral View of the Nasal Capsule

BF - Basicranial fenestra.

CDN - Cartilago ductus nasopalatini.

LON - Lamina orbito-nasalis.

LTA - Lamina transversalis anterior.

LTP - Lamina transversalis posterior.

NS - Nasal septum.

PN - Paranasal cartilage.

PS - Paraseptal cartilage.

PT - Parietotectal cartilage.

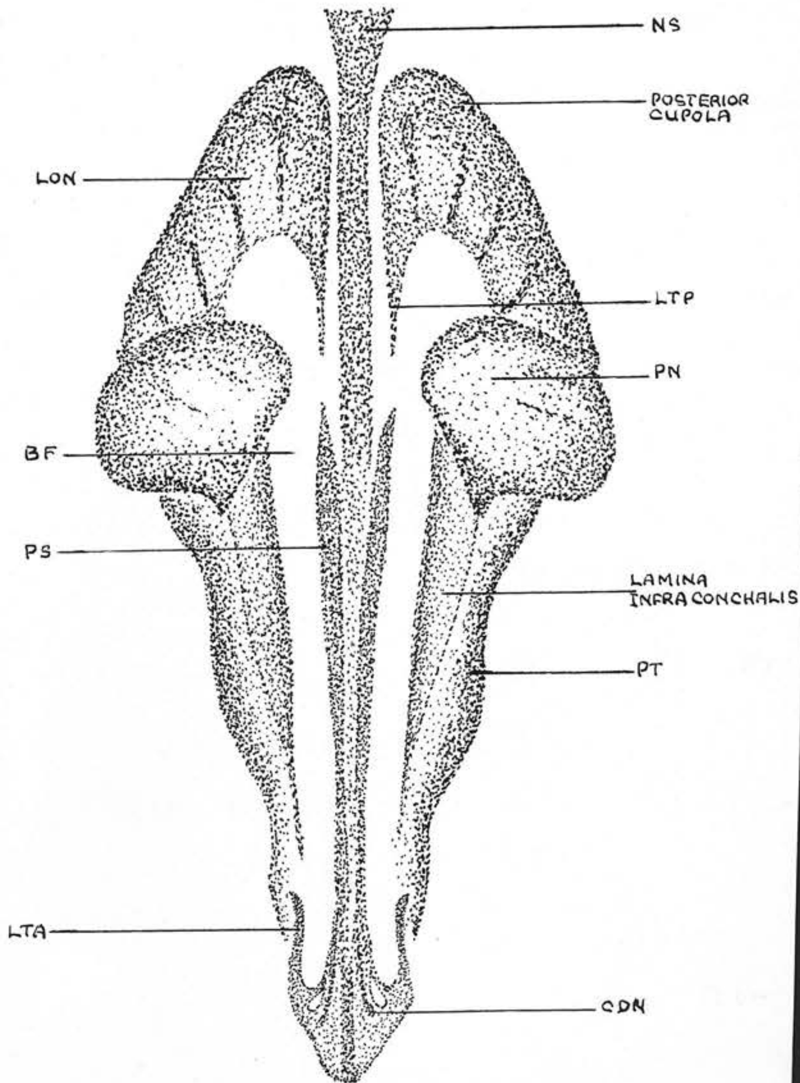

Fig. LXII

Stage XI

G 13 - 25 mm. H.H.

Ventral View of the Nasal Capsule

Plate LXIII

Stage XI

G 28 - 22 mm. H.H.

Wax Model - Lateral View of the Anterior Region
of the Nasal Capsule

CDN - Cartilago ductus nasopalatini.

LTA - Lamina transversalis anterior.

NS - Nasal septum.

PAC - Palatine cartilage.

PAS - Processus alaris superior.

PS - Paraseptal cartilage.

TN - Tectum nasi.

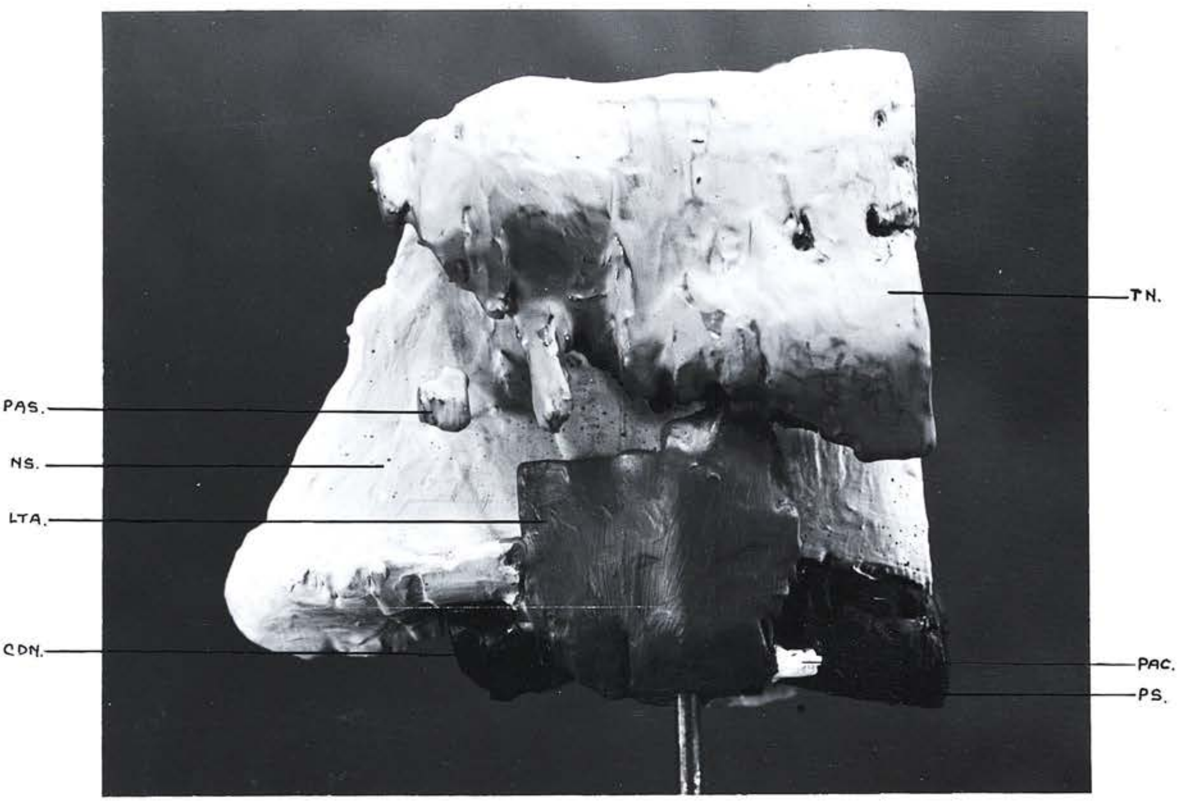

PLATE LXIII Stage XI.
G28 22 mm·H.H.
WAX MODEL — LATERAL VIEW OF THE
ANTERIOR REGION OF NASAL CAPSULE.

PLATE LXIII. STAGE XI.
G28 22 mm. H.H.

Plate LXIV

Stage XI

G 28 - 22 mm. H.H.

Wax Model - Posterior View of Anterior Region of the Nasal Capsule

ATT - Atrioturbinal.

LTA - Lamina transversalis anterior.

NS - Nasal septum.

PAC - Palatine cartilage.

PS - Paraseptal cartilage.

SSS - Sulcus supraseptalis.

TN - Tectum nasi.

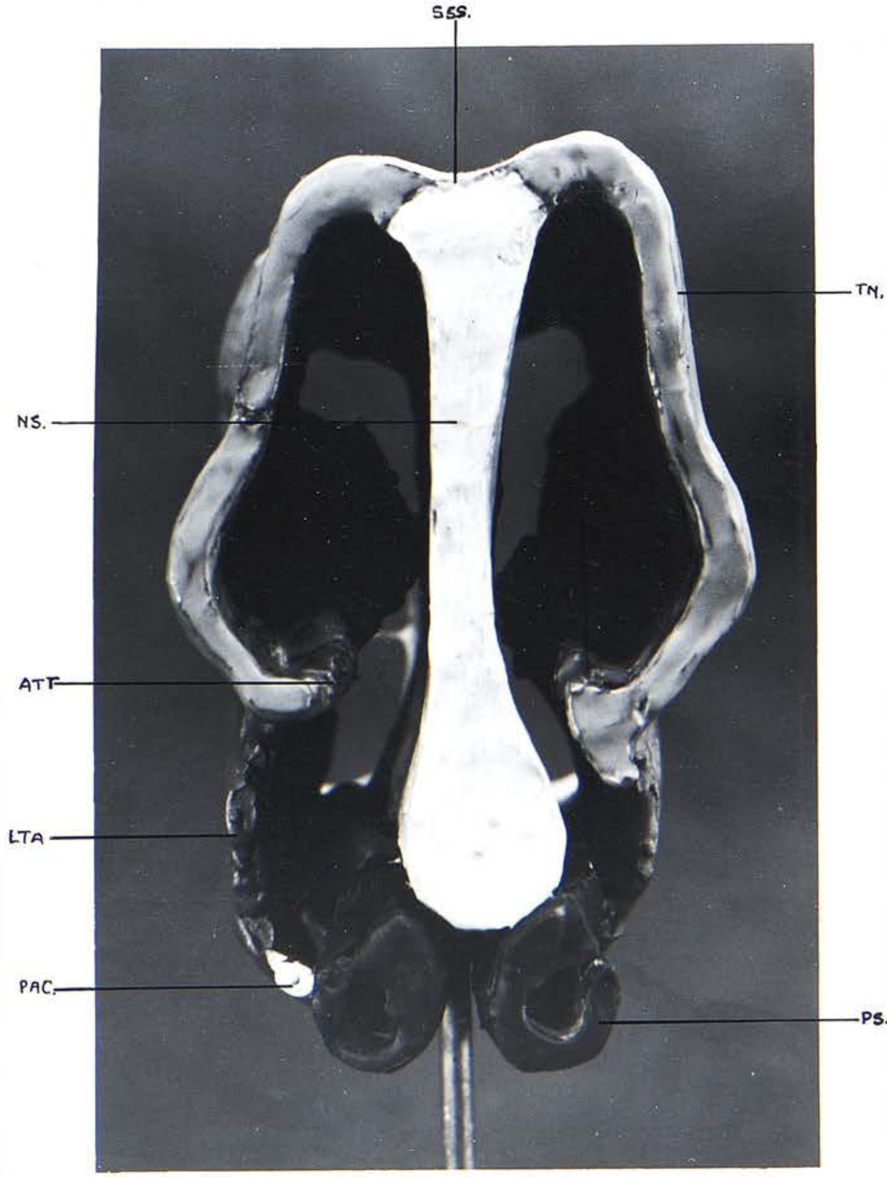

PLATE LXIV. STAGE XI.
G28 22 mm H.H.
WAX MODEL – POSTERIOR VIEW OF THE ANTERIOR REGION OF NASAL CAPSULE.

PLATE LXIV. STAGE XI.
G28 22 mm H.H.
WAX MODEL - POSTERIOR VIEW
OF THE ANTERIOR REGION OF
NASAL CAPSULE.

Fig. LXV

Stage XI

E 12 - 27 mm. H.H.

Medial View of the Posterior Region
of the Lateral Wall of the Nasal Capsule

ET - Ethmoturbinal.

MT - Maxillo-turbinal.

NT - Nasoturbinal.

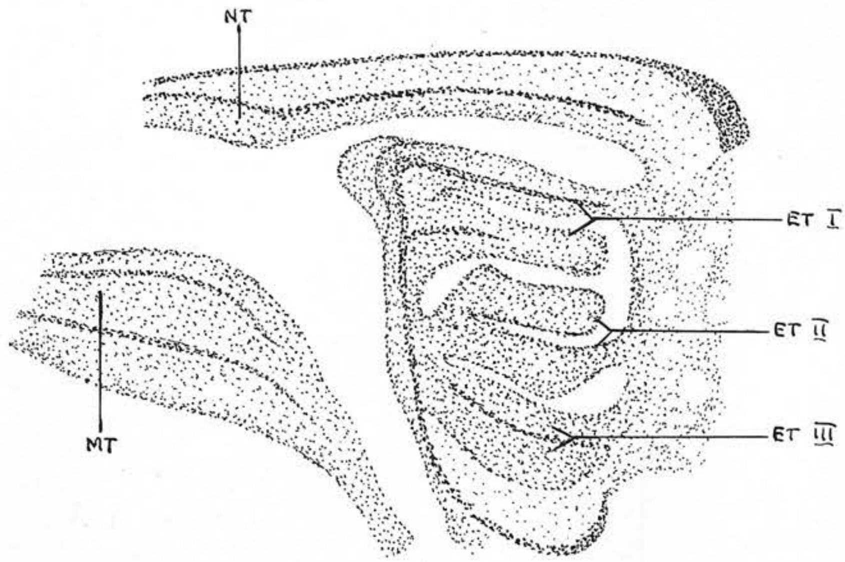

Fig. LXV Stage XI

E 12 - 27 mm. H.H.

Medial View of the Posterior Region of the Lateral Wall of the Nasal Capsule.

Fig. LXVI

Stage XI

E 12 - 27 mm. H.H.

Medial View of the Lateral Wall
of the Nasal Capsule

ATT - Atrioturbinal.

ET - Ethmoturbinal.

LTA - Lamina transversalis anterior.

MT - Maxillo-turbinal.

NT - Nasoturbinal.

PN - Paranasal cartilage.

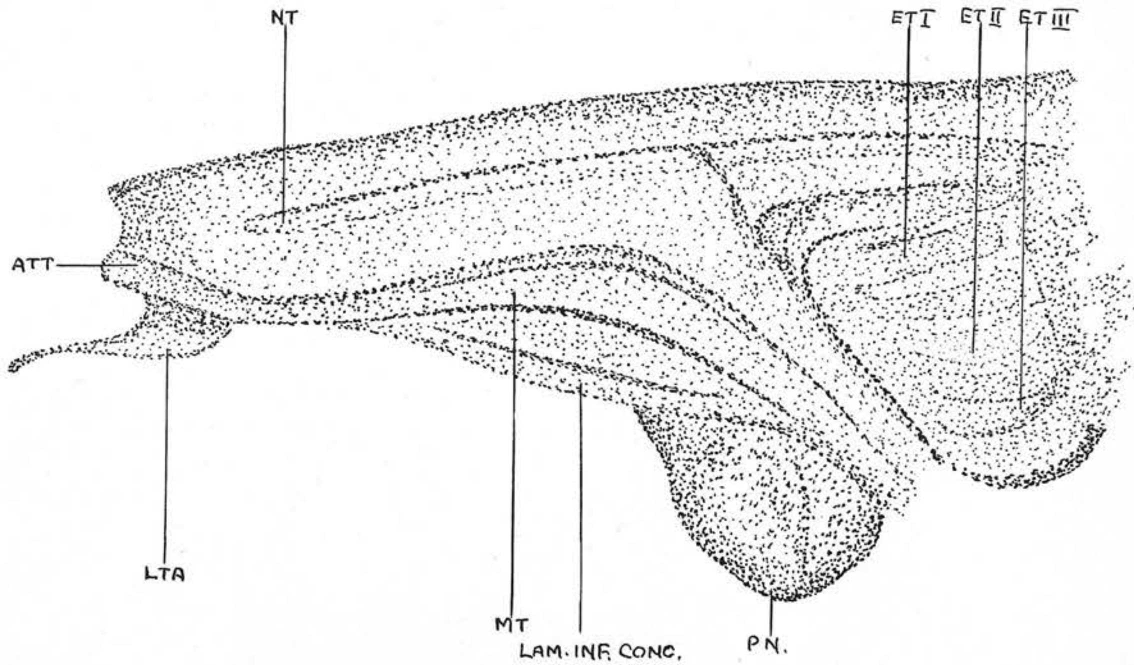

Fig. LXVI Stage XI E 12 - 27 mm. H.H.

Medial View of the Lateral Wall of the Nasal Capsule

Plate LXVII

Stage XI

G 6 - 19 mm. H.H.

Lateral View

COP - Orbito-parietal commissure.

CSE - Sphenethmoid commissure.

FLP - Fissura lamina parietalis.

FO - Optic foramen.

FOI - Fissura occipito-capsularis inferior.

MC - Meckel's cartilage.

NC - Nasal capsule.

OA - Occipital arch.

ONF - Orbito-nasal fissure.

ORC - Orbital cartilage.

PPL - Parietal plate.

SH - Stylohyal cartilage.

SOC - Supraoccipital cartilage.

SPF - Sphenoparietal fontanelle.

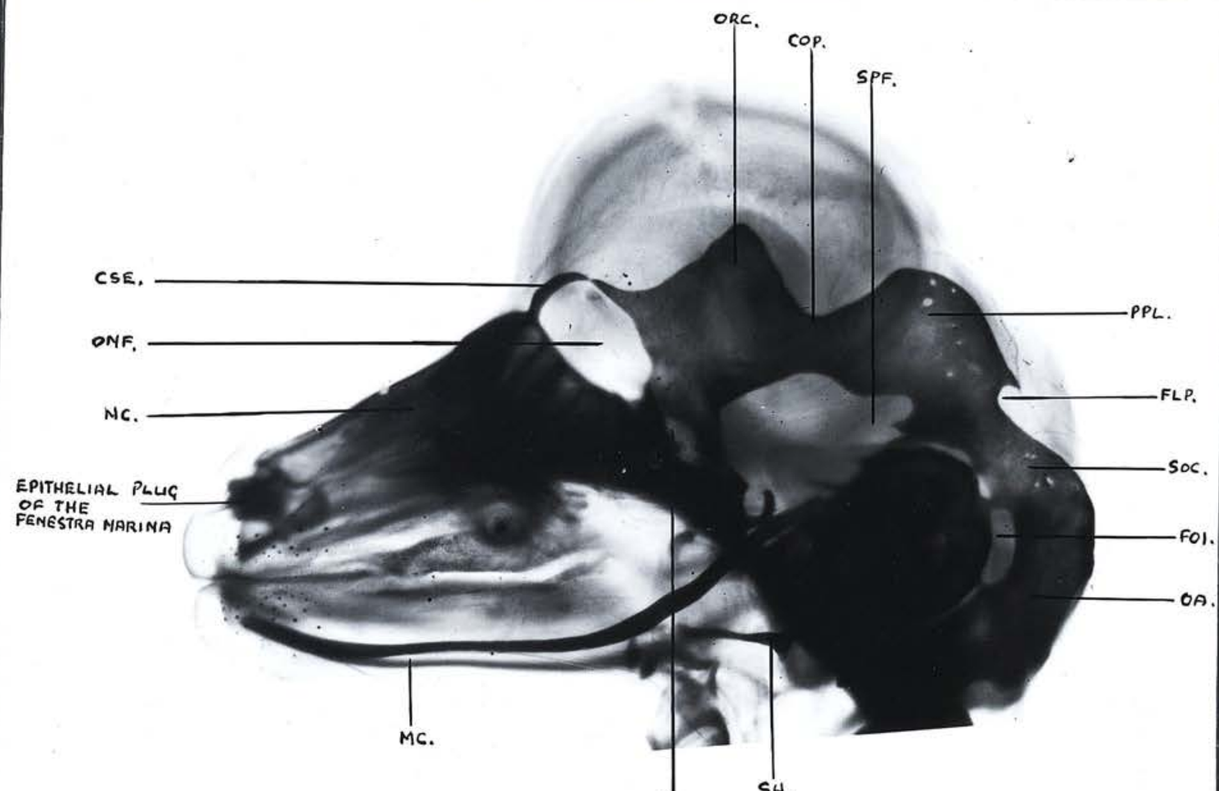

PLATE LXVII STAGE XI.
G6. — 19 mm. H. H.
LATERAL VIEW.

Fig. LXVIII

Stage XI

G 13 - 25 mm. H.H.

Cartilages of the Future Auditory Capsule

FOV - Fenestra ovalis.

I - Incus.

M - Malleus.

S - Stapes.

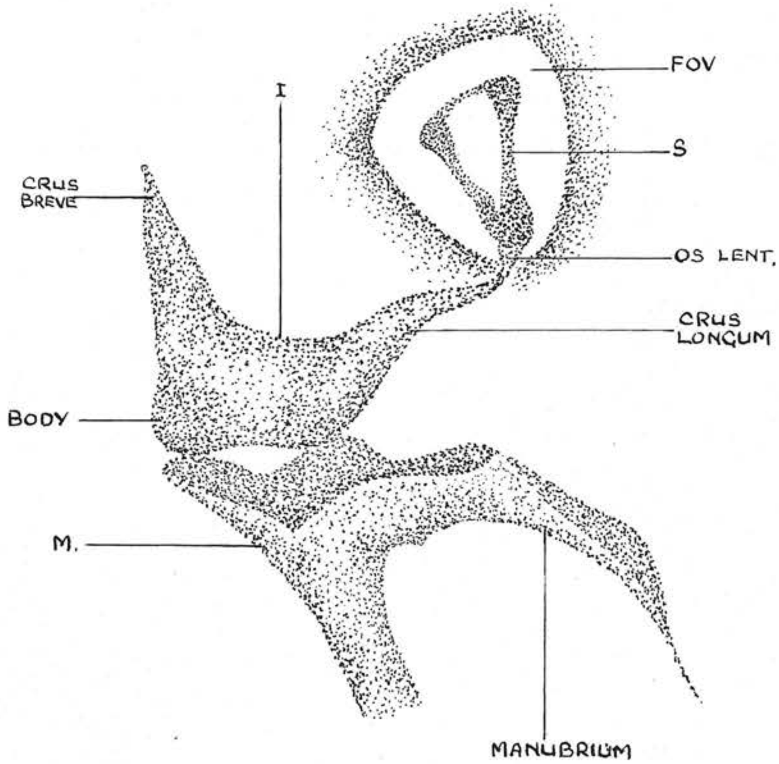

Fig. LXVIII

Stage XI

G 13 - 25 mm. H.H.

Cartilages of the future Auditory Ossicles

Plate LXIX

Stage XI

E 12 - 27 mm. H.H.

Medial View of the Lateral Wall
of the Nasal Capsule

ATT - Atrioturbinal.

ET - Ethmoturbinal.

MT - Maxillo-turbinal.

NT - Nasoturbinal.

PN - Paranasal cartilage.

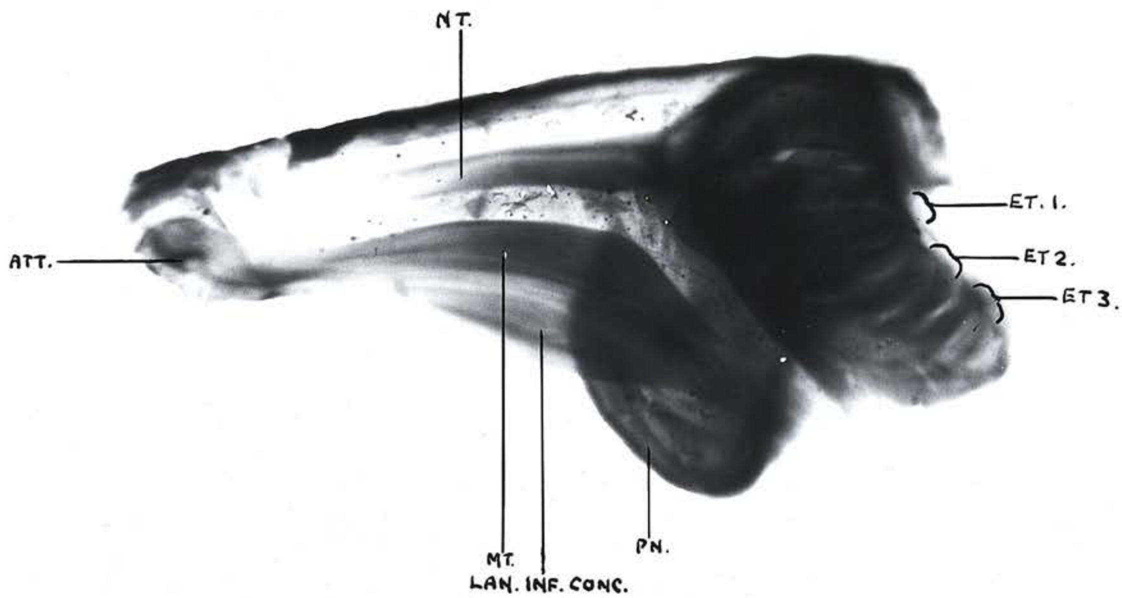

PLATE LXIX. STAGE XI.
E 12 - 27 mm. H.H.
MEDIAL VIEW OF THE LATERAL
WALL OF THE NASAL CAPSULE.

Fig. LXX

Stage XI

G 13 - 25 mm. H.H.

Lateral View of the Hyoid Apparatus

BH - Basihyal cartilage.

CH - Ceratohyal.

CRC - Cricoid cartilage.

CRP - Crista parotica.

TH - Thyrohyal cartilage.

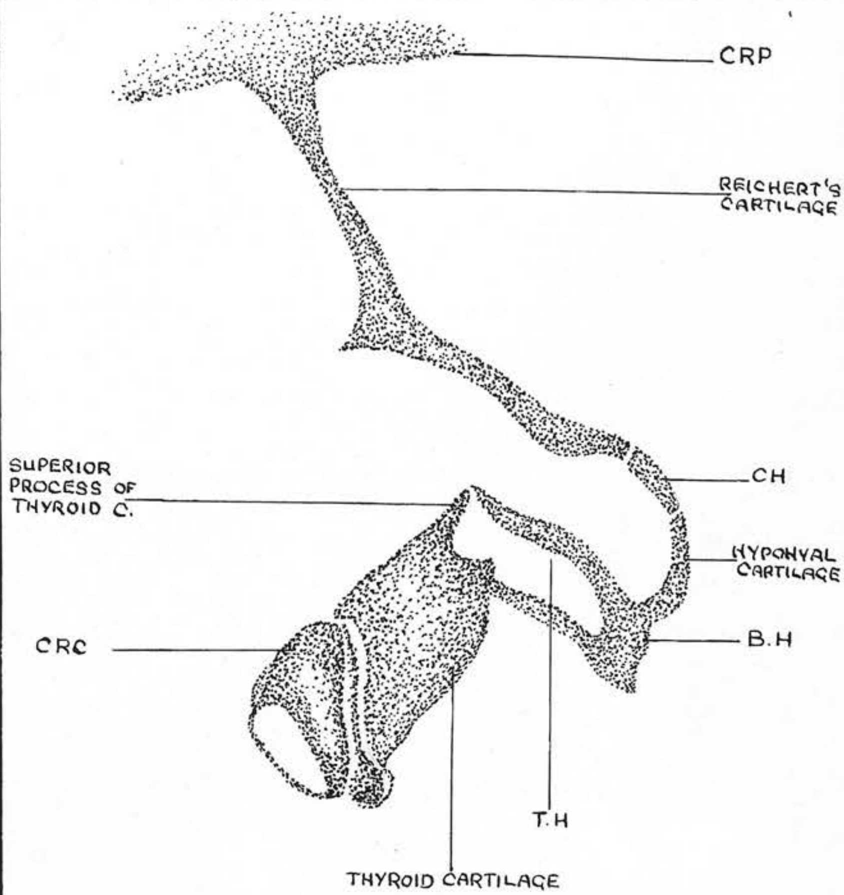

Fig. LXX

Stage XI

G 13 - 25 mm. H.H.

Lateral View of the Hyoid Apparatus

Plate LXXI

Stage XI

G 13 - 25 mm. H.H.

Lateral View of the Hyoid Apparatus

ACTC - Anterior cornu of the thyroid cartilage.

CH - Ceratohyal.

CRC - Cricoid cartilage.

SH - Stylohyal cartilage.

TC - Thyroid cartilage.

TH - Thyrohyal cartilage.

TR - Tracheal ring.

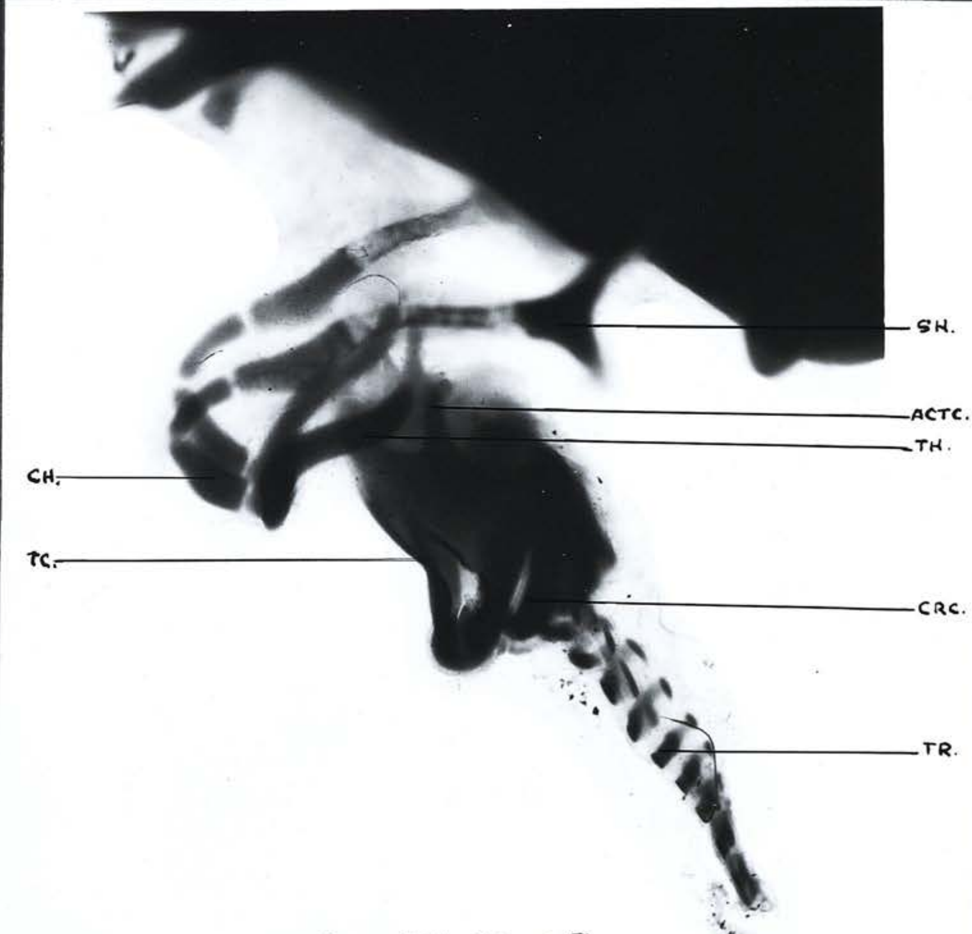

PLATE LXXI, STAGE XI
G13 - 25 mm. H.H.
LATERAL VIEW OF THE
HYOID APPARATUS.

Fig. LXXII

Stage XI

G 13 - 25 mm. H.H.

Ventral View of the Hyoid Apparatus

BH - Basihyal cartilage.

CH - Ceratohyal cartilage.

CRC - Cricoid cartilage.

TH - Thyrohyal cartilage.

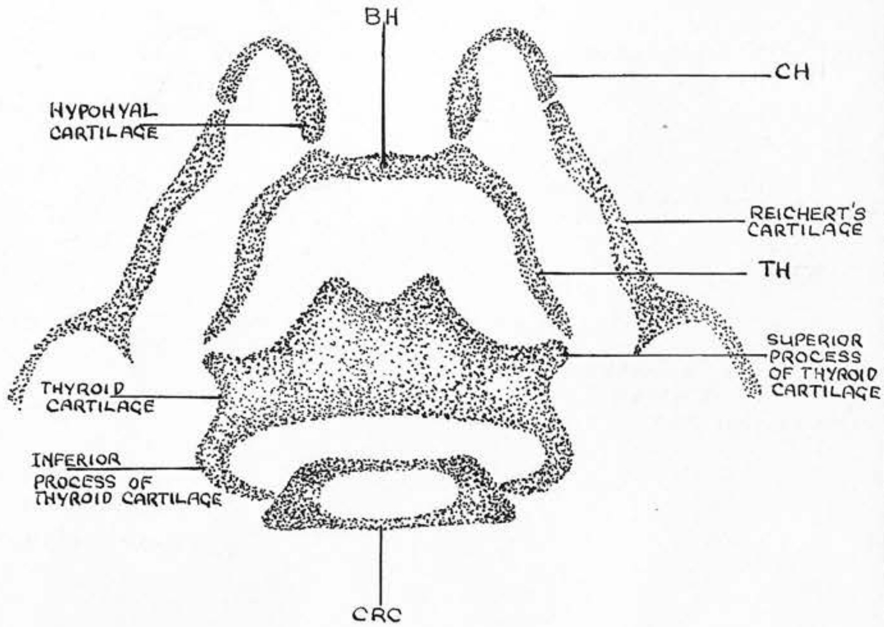

Fig. LXXII

Stage XI

G 13 - 25 mm. H.H.

Ventral View of the Hyoid Apparatus

Plate LXXIII

Stage XI

G 28 - 22 mm. H.H.

Transverse Section of the Anterior Region
of the Nasal Capsule

ATT - Atrioturbinal.

CDN - Cartilago ductus nasopalatini.

NS - Nasal septum.

NPD - Naso-palatine duct.

PAI - Processus alaris inferior.

PAS - Processus alaris superior.

PMX - Premaxillary bone.

SSS - Sulcus supraseptalis.

TG - Tongue.

TN - Tectum nasi.

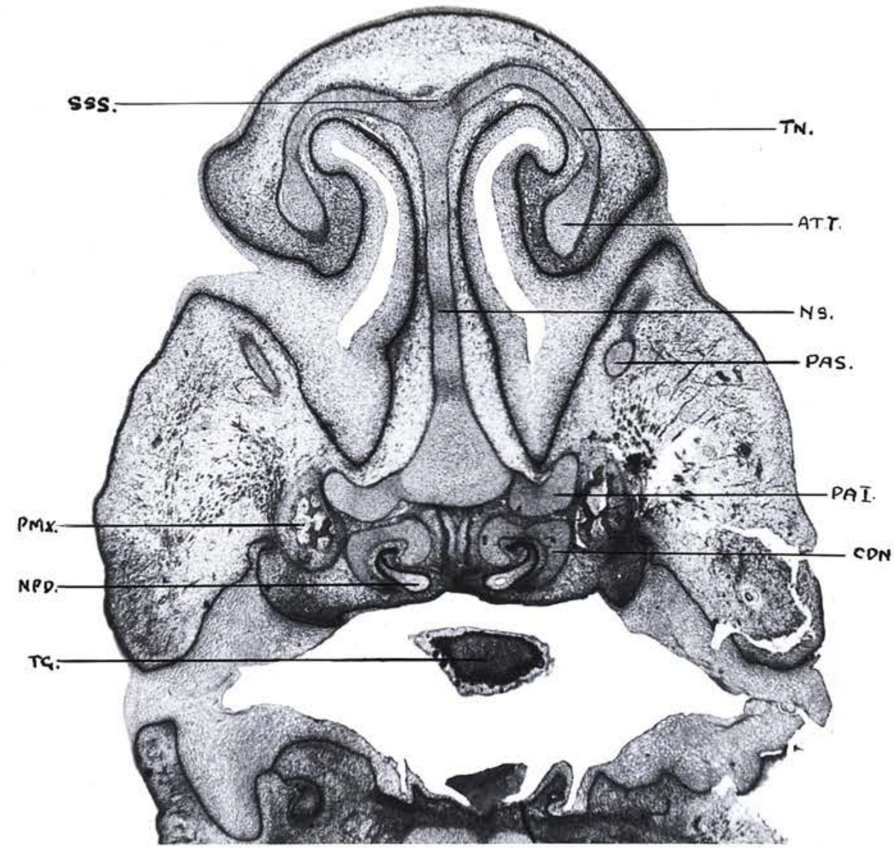

PLATE LXXIII G 28.-22 mm H.H.
TRANSVERSE SECTION OF THE
ANTERIOR REGION OF THE
NASAL CAPSULE.
STAGE XI.

Plate LXXIV

Stage XI

G 28 - 22 mm. H.H.

Transverse Section of the Middle
of the Nasal Capsule

DLNG - Duct of lateral nasal gland.

JO - Jacobson's organ.

MT - Maxillo-turbinal.

NLD - Naso-lachrymal duct.

NS - Nasal septum.

NT - Nasoturbinal.

PMX - Premaxillary bone.

PS - Paraseptal cartilage.

SSS - Sulcus supraseptalis.

TG - Tongue.

TN - Tectum nasi.

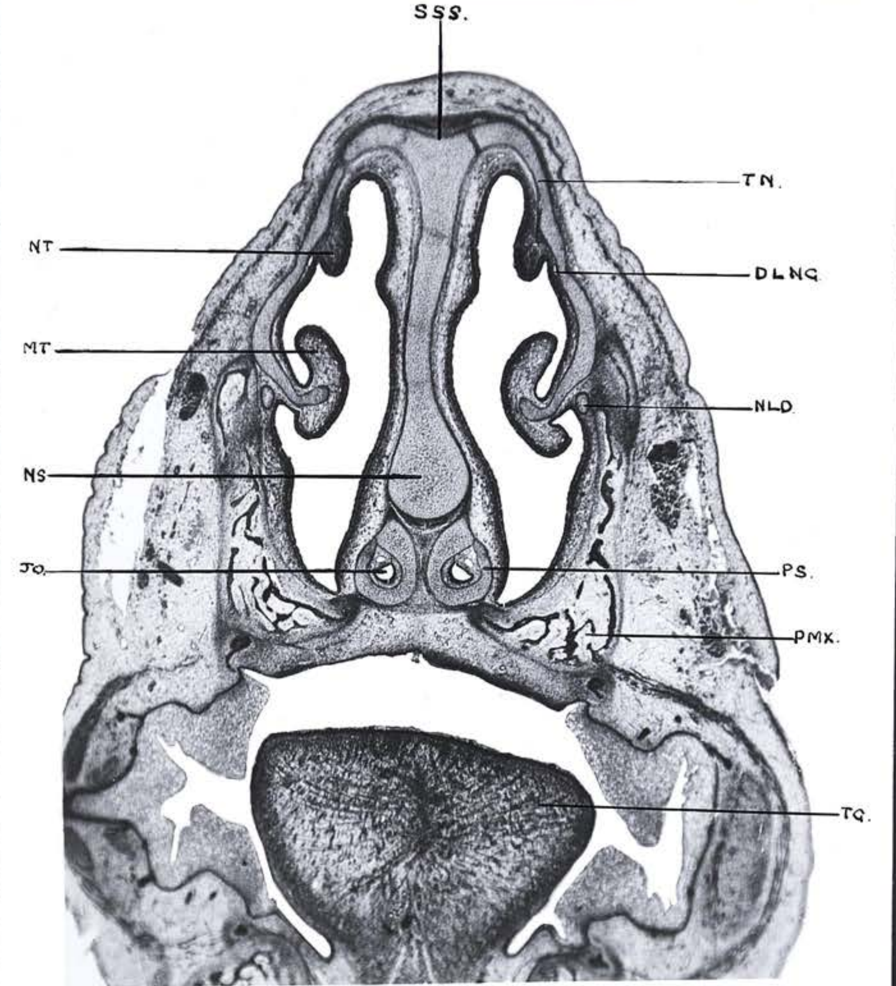

PLATE LXXIV.
G28 - 22 mm. H.H.
TRANSVERSE SECTION OF THE
MIDDLE OF THE NASAL CAPSULE.
STAGE XI.

Plate LXXV

Stage XI

G 28 - 22mm. H.H.

Transverse Section of the Anterior Region
of the Nasal Capsule

ATT - Atrioturbinal.

DLNG - Duct of lateral nasal gland.

JO - Jacobson's organ.

LTA - Lamina transversalis anterior.

NLD - Naso-lachrymal duct.

NS - Nasal septum.

PMX - Premaxillary bone.

PS - Paraseptal cartilage.

SSS - Sulcus supraseptalis.

TG - Tongue.

TN - Tectum nasi.

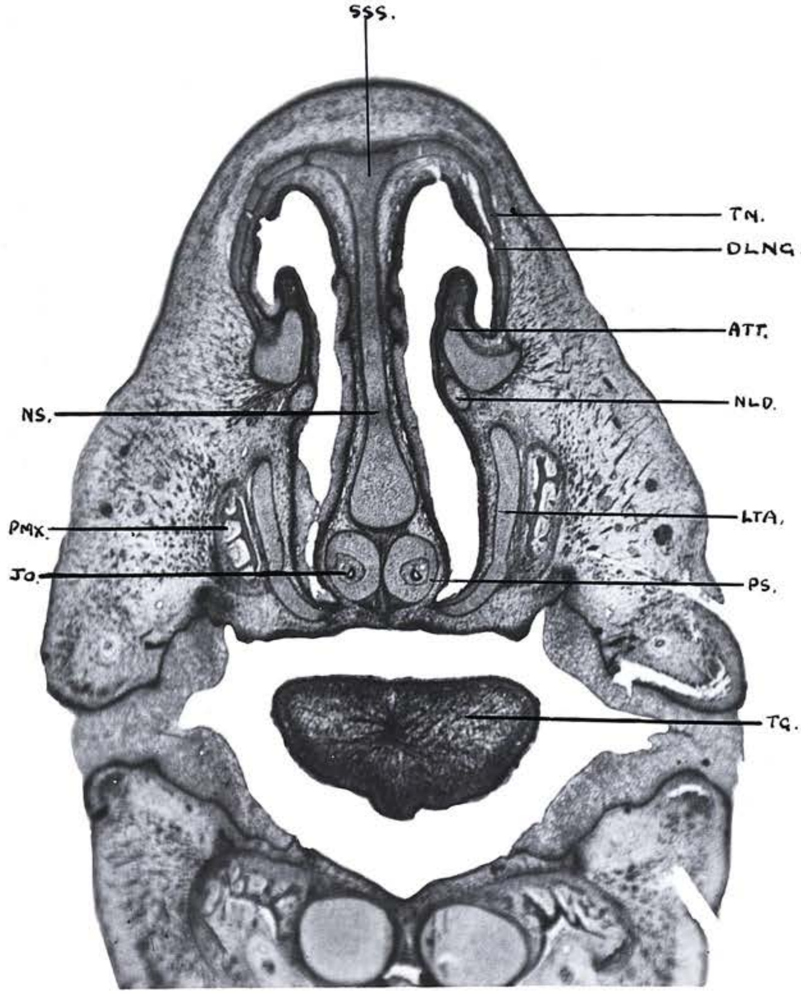

PLATE LXXV G 28 - 22mm H.H.
TRANSVERSE SECTION OF THE
ANTERIOR REGION OF THE
NASAL CAPSULE.
STAGE XI.

Plate LXXVI

Stage XI

G 28 - 22 mm. H.H.

Transverse Section of the Anterior Region
of the Nasal Capsule

ATT - Atrioturbinal.

DLNG - Duct of lateral nasal gland.

JO - Jacobson's organ.

LTA - Lamina transversalis anterior.

NLD - Naso-lachrymal duct.

PAC - Palatine cartilage.

PMX - Premaxillary bone.

PS - Paraseptal cartilage.

SSS - Sulcus supraseptalis.

TN - Tectum nasi.

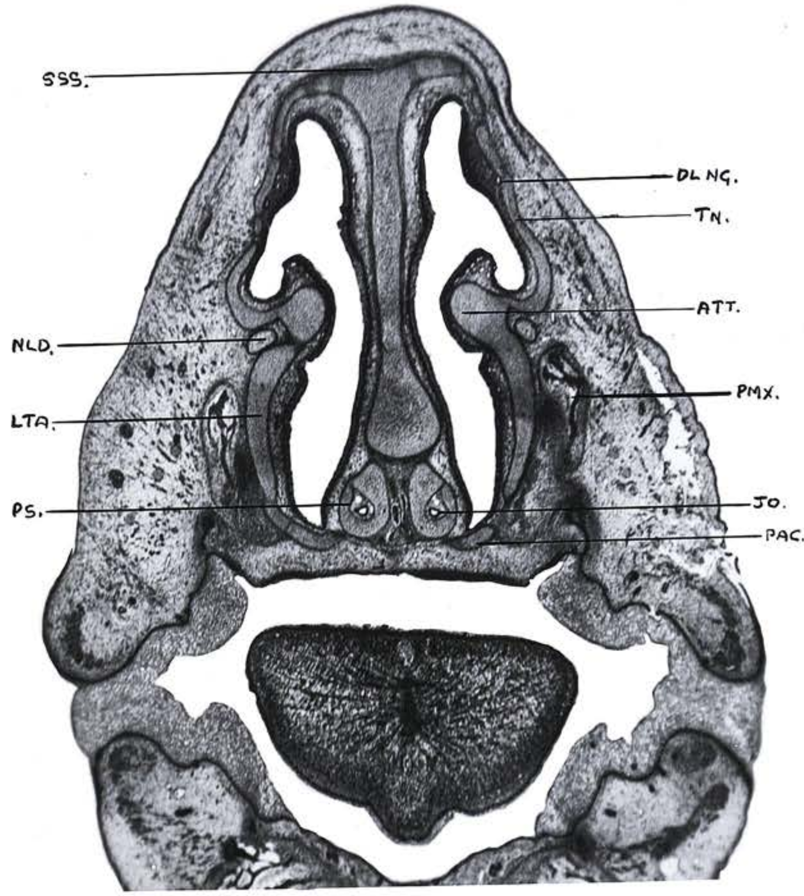

PLATE LXXVI G 28 - 22 mm H.H.
TRANSVERSE SECTION OF THE
ANTERIOR REGION OF THE
NASAL CAPSULE.
STAGE XI.

Plate LXXVII

Stage XI

G 28 - 22 mm. H.H.

Transverse Section of the Posterior Third
of the Nasal Capsule

CS - Crista semicircularis.

DLNG - Duct of lateral nasal gland.

JO - Jacobson's organ.

MAX - Maxillary bone.

MT - Maxillo-turbinal.

MXP - Palatine process of maxilla.

NAS - Nasal bone.

NLD - Naso-lachrymal duct.

NS - Nasal septum.

PN - Paranasal cartilage.

PS - Paraseptal cartilage.

SSS - Sulcus supraseptalis.

VB - Vomer bone.

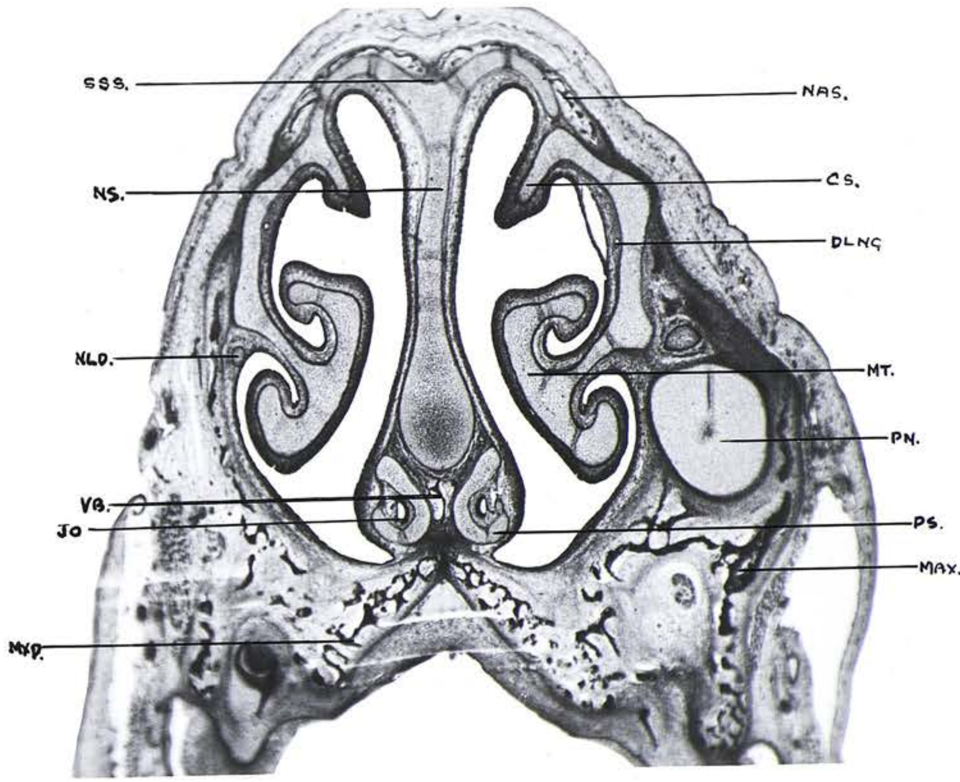

PLATE LXXVII G28 - 22 mm H.H.
TRANSVERSE SECTION OF THE
POSTERIOR THIRD OF THE
NASAL CAPSULE.
STAGE XI.

Plate LXXVIII

Stage XI

G 28 - 22 mm. H.H.

Transverse Section of the Posterior Region of the Nasal Capsule.

CS - Crista semicircularis.

ET - Ethmoturbinal.

FT - Frontoturbinal.

MAX - Maxillary bone.

MT - Maxillo-turbinal.

MXP - Palatine process of maxilla.

NS - Nasal septum.

NT - Nasoturbinal.

PN - Paranasal cartilage.

RF - Recessus frontalis.

RM - Recessus maxillaris.

SSS - Sulcus supraseptalis.

VB - Vomer bone.

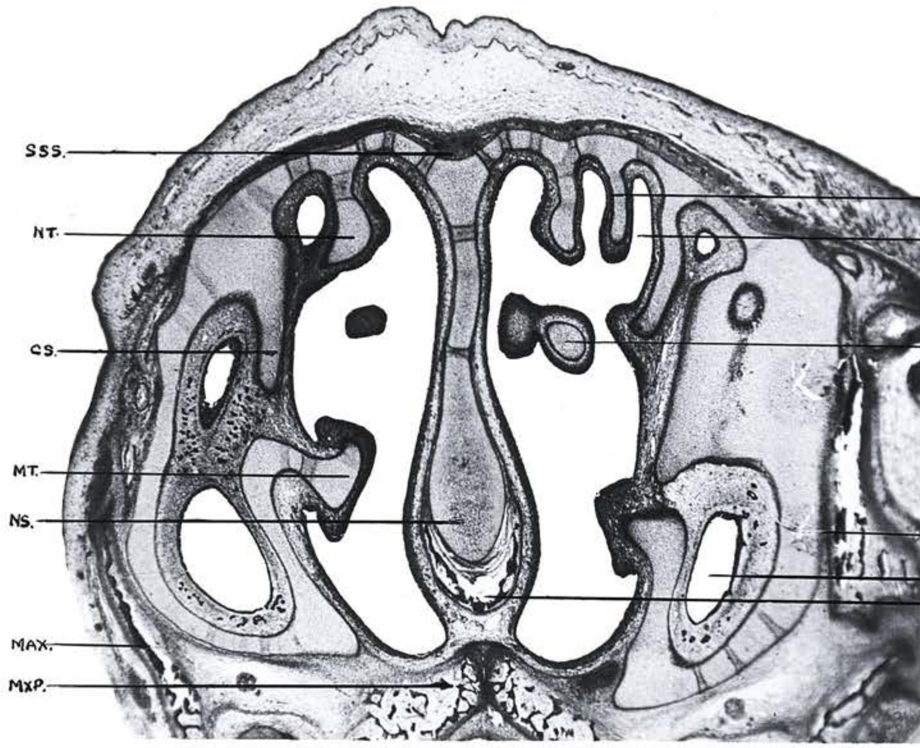

PLATE LXXVIII G28 - 22 mm H.H.
TRANSVERSE SECTION OF THE.
POSTERIOR REGION OF THE
NASAL CAPSULE.
STAGE XI.

Plate LXXIX

Stage XI

G 28 - 22 mm. H.H.

Transverse Section of the Posterior Region
of the Nasal Capsule

ET - Ethmoturbinal.

FRO - Frontal bone.

JUG - Jugal bone.

LC - Lamina cribrosa.

LTP - Lamina transversalis posterior.

MAX - Maxillary bone.

NS - Nasal septum.

PAB - Palatine bone.

SSS - Sulcus supraseptalis.

VB - Vomer bone.

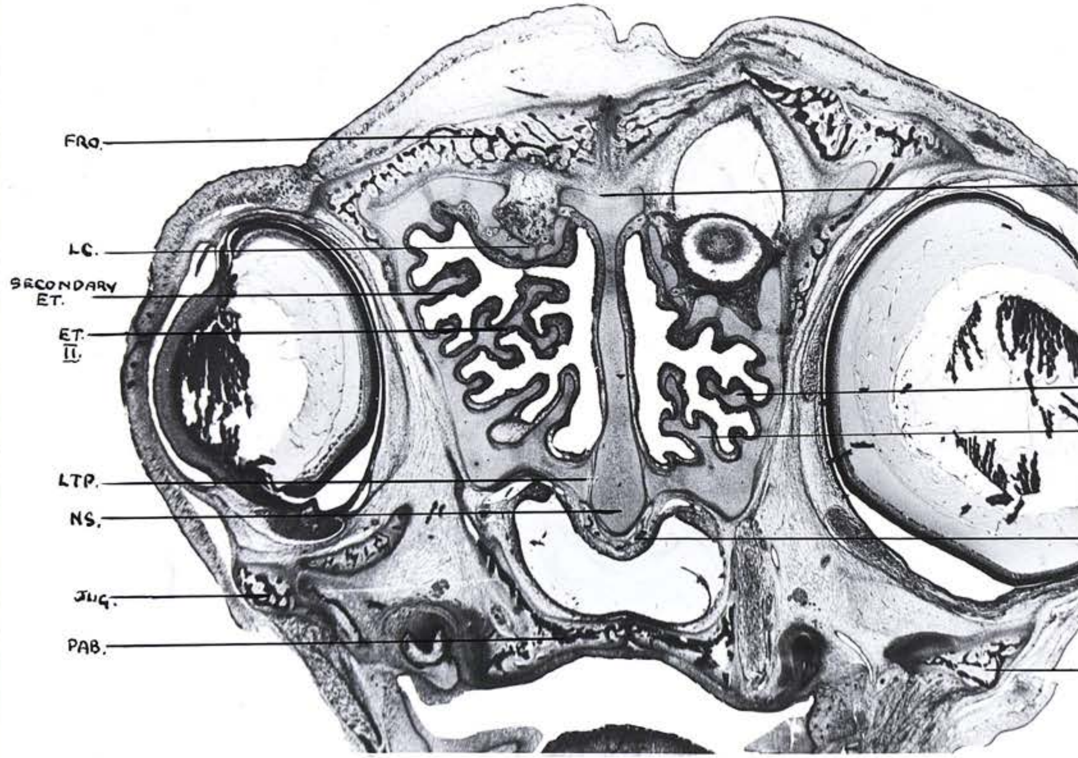

PLATE LXXIX. G28-22mm H.H.
TRANSVERSE SECTION OF THE
POSTERIOR REGION OF THE
NASAL CAPSULE.
STAGE XI.

Plate LXXX

Stage XI

G 28 - 22 mm. H.H.

Transverse Section through the Optic Region
of the Chondrocranium

FRO - Frontal bone.

ON - Optic nerve.

ORC - Orbital cartilage.

P - Parachordal or basal plate.

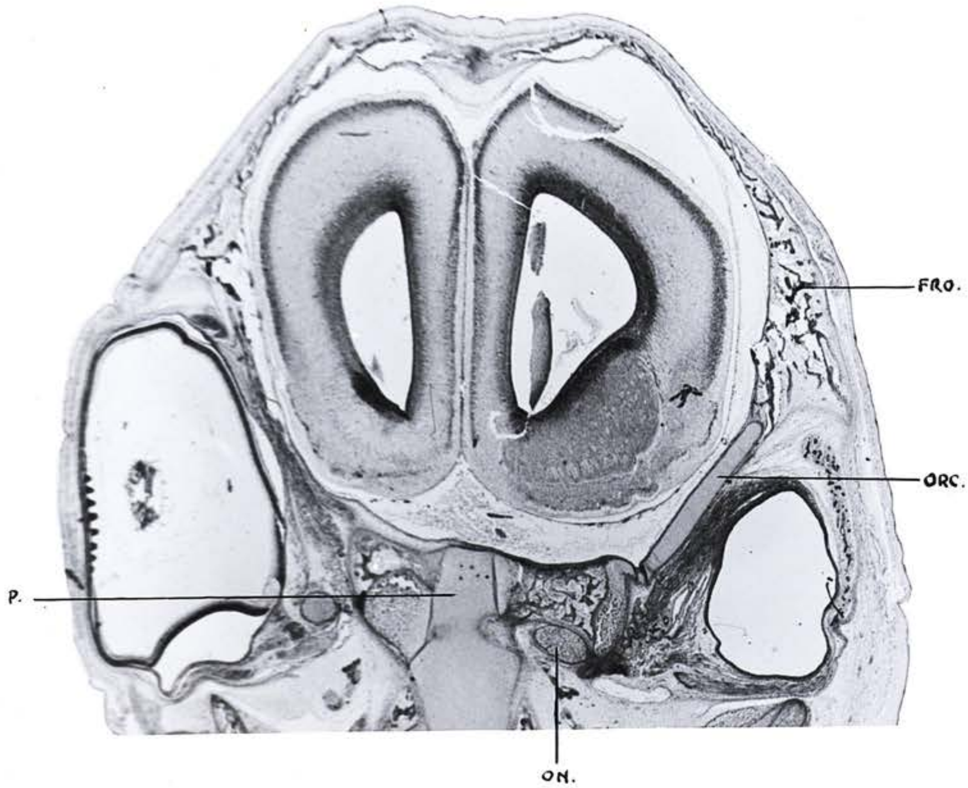

PLATE LXXX G28 – 22 mm. H.H.
TRANSVERSE SECTION THROUGH
THE OPTIC REGION OF THE
CHONDROCRANIUM.
STAGE XI.

Plate LXXXI

Stage XI

G 13 - 25 mm. H.H.

Ventral View of the Entire Chondrocranium

BH - Basihyal cartilage.

CH - Ceratohyal cartilage.

FM - Foramen magnum.

MC - Meckel's cartilage.

SH - Stylohyal cartilage.

TH - Thyrohyal cartilage.

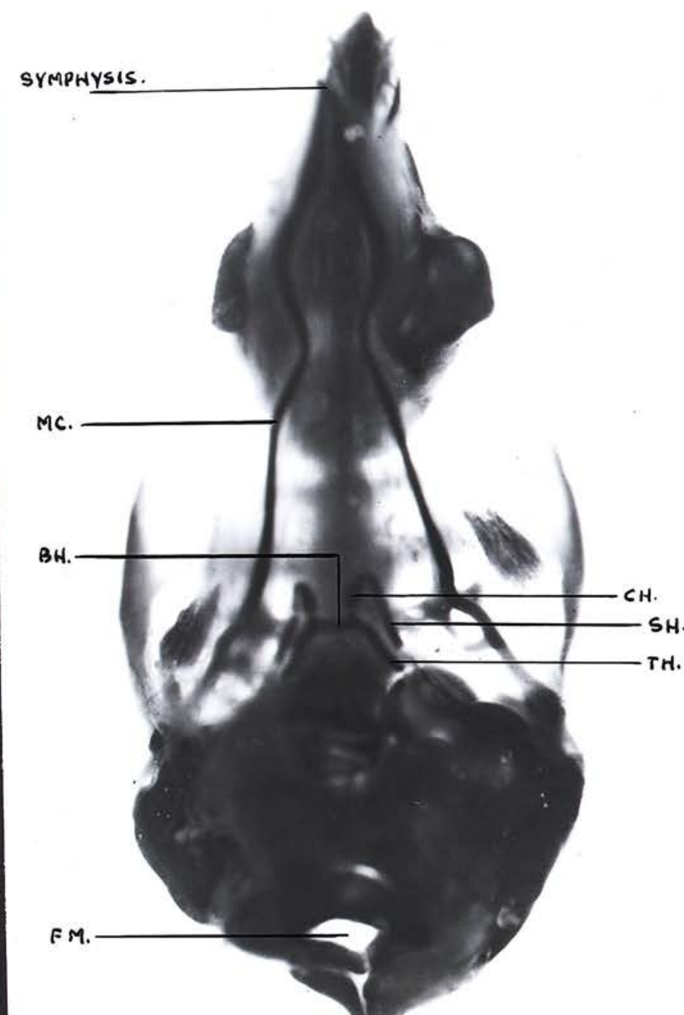

PLATE LXXXI, STAGE XI
G13 - 25 mm. H.H.
VENTRAL VIEW OF THE
ENTIRE CHONDROCRANIUM.

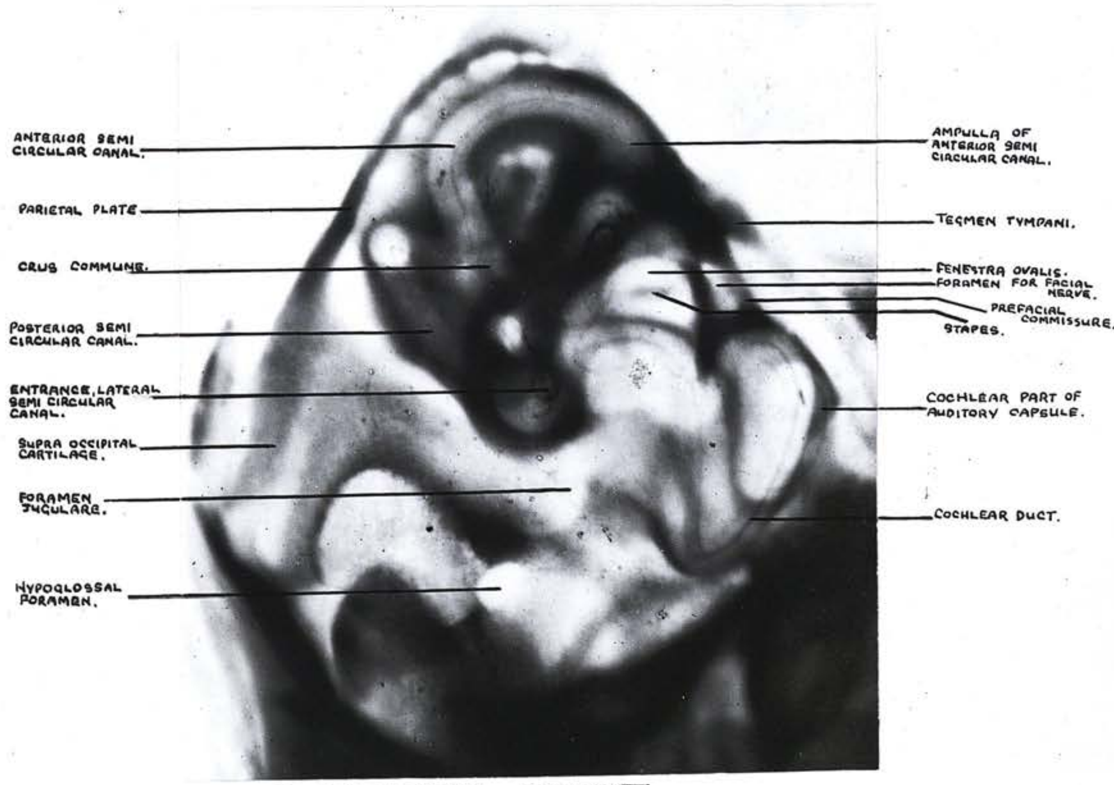

PLATE LXXXII STAGE XI.

G 13 25 mm H. H.

MEDIAL VIEW OF AUDITORY CAPSULE.

Plate LXXXIII

Stage XI

G 28 - 22 mm. H.H.

Transverse Section of the Auditory Capsule

CD - Cochlear duct.

CAT - Cavum tympani.

GS - Ganglion semilunar.

I - Incus.

M - Malleus.

P - Parachordal or basal plate.

RC - Reichert's cartilage.

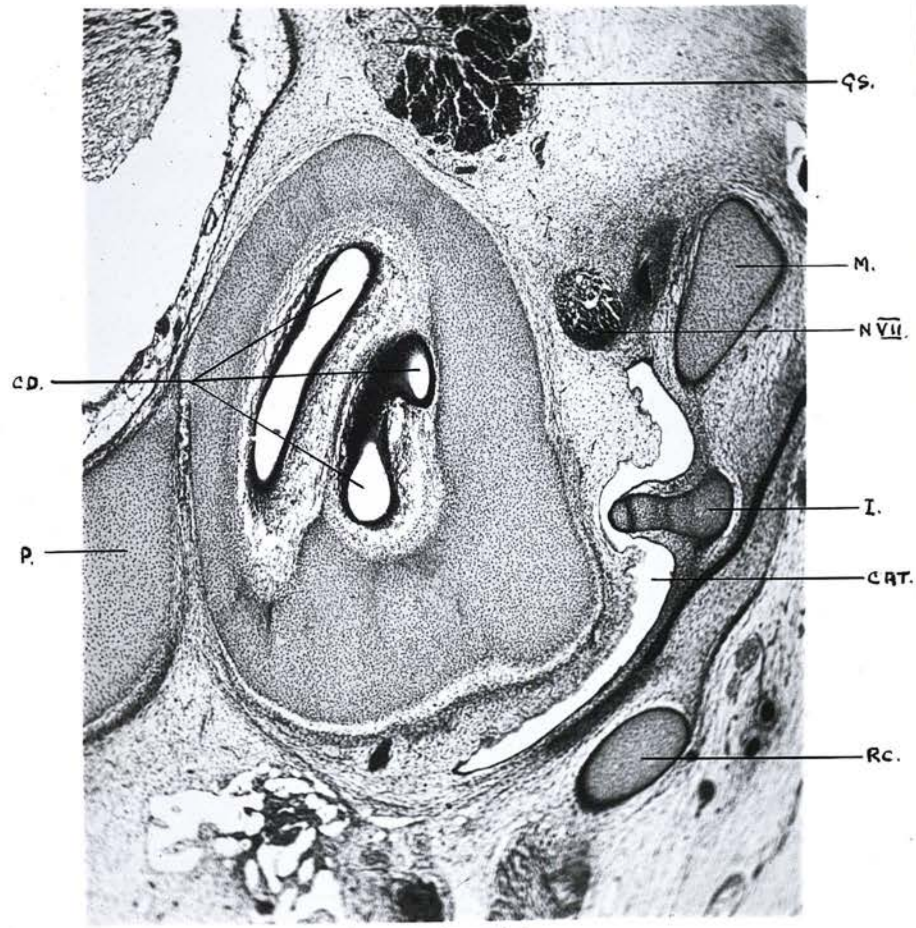

PLATE LXXXIII
G 28-22 mm. H. H.
TRANSVERSE SECTION
OF THE AUDITORY CAPSULE.
STAGE XI.

Plate LXXXIV

Stage XI

G 28 - 22 mm. H.H.

Transverse Section of the Auditory Capsule

CD - Cochlear duct.

CAT - Cavum tympani.

GS - Ganglion semilunar.

I - Incus.

M - Malleus.

MAE - Meatus acusticus externus.

RC - Reichert's cartilage.

SSP - Septum spirale.

TEN TY - Tensor tympani.

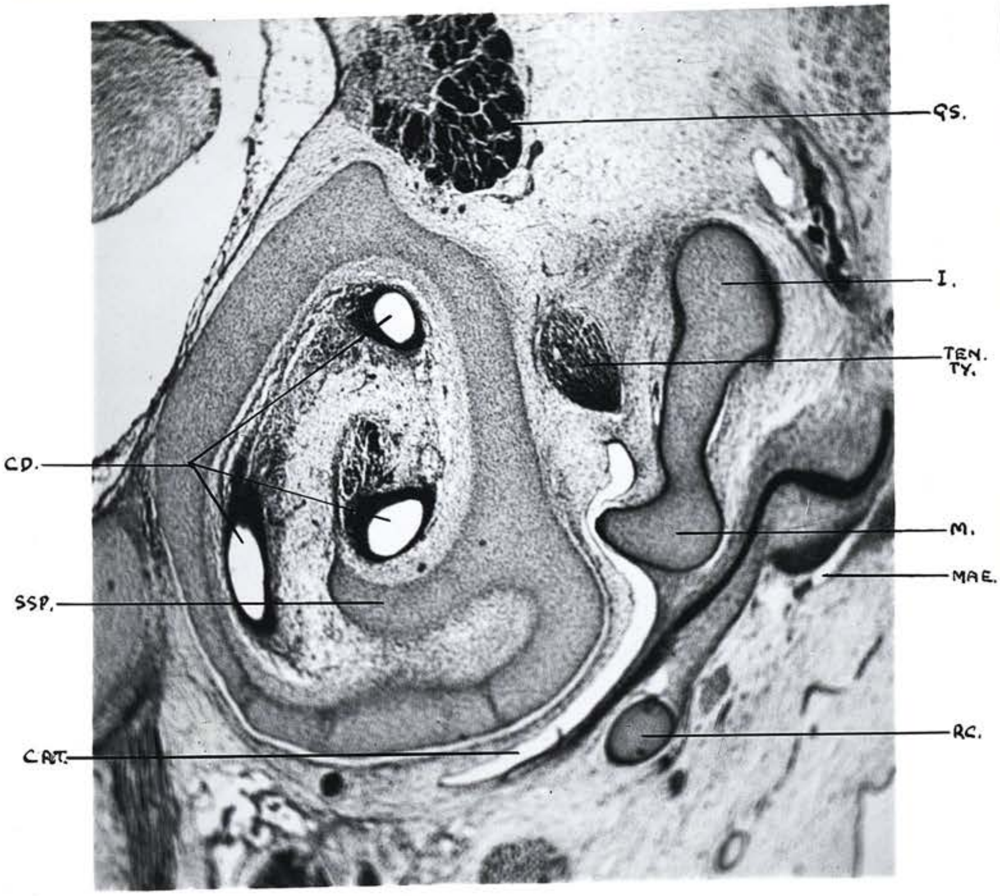

PLATE LXXXIV.
G 28 - 22 mm. H.H.
TRANSVERSE SECTION
OF THE AUDITORY CAPSULE.
STAGE XI.

Plate LXXXV

Stage XI

G 28 - 22 m.m. H.H.

Transverse Section of the Auditory Capsule

CD - Cochlear duct.

CAT - Cavum tympani.

G GEN - Ganglion geniculata.

GS - Ganglion semilunar.

I - Incus.

RC - Reichert's cartilage.

S - Stapes.

SSP - Septum spirale.

TTY - Tegmen tympani.

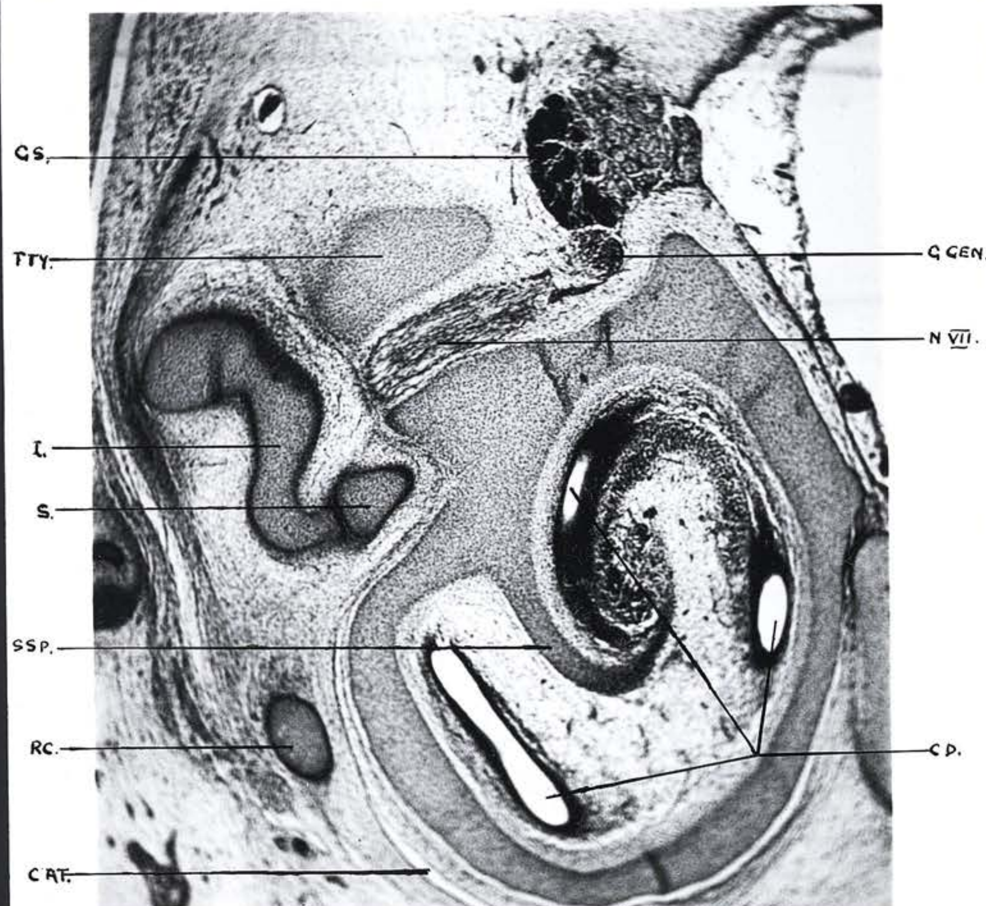

PLATE LXXXV.
G 28 22 mm. H.H.
TRANSVERSE SECTION
OF THE AUDITORY CAPSULE
STAGE XI.

Plate LXXXVI

Stage XI

G 28 - 22 m.m. H.H.

Transverse Section of the Auditory Capsule

CD - Cochlear duct.

CAT - Cavum tympani.

FOV - Fenestra ovalis.

I - Incus.

PFC - Prefacial commissure.

RC - Reichert's cartilage.

S - Stapes.

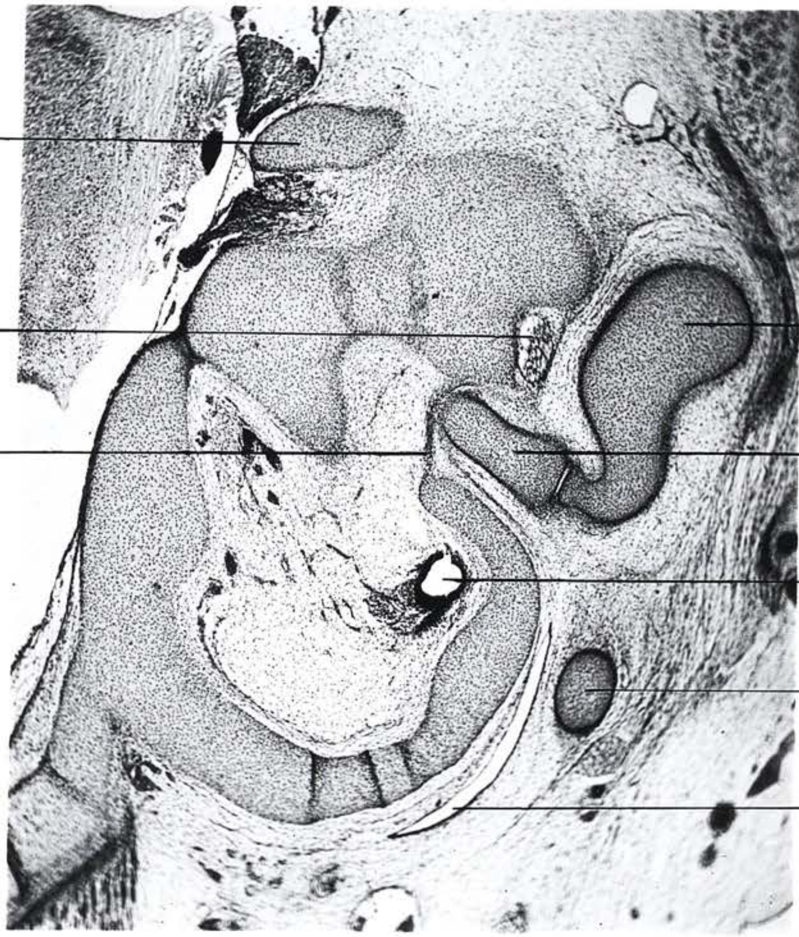

PLATE LXXXVI.
G 28-32 mm. H.H.
TRANSVERSE SECTION
OF THE AUDITORY CAPSULE
STAGE XI.

Plate LXXXVII

Stage XI

G 28 - 22 mm. H.H.

Transverse Section of the Auditory Capsule

CD - Cochlear duct.

CAT - Cavum tympani.

G GEN - Ganglion geniculata.

GS - Ganglion semilunar.

I - Incus.

PFC - Prefacial commissure.

RC - Reichert's cartilage.

TTY - Tegmen tympani.

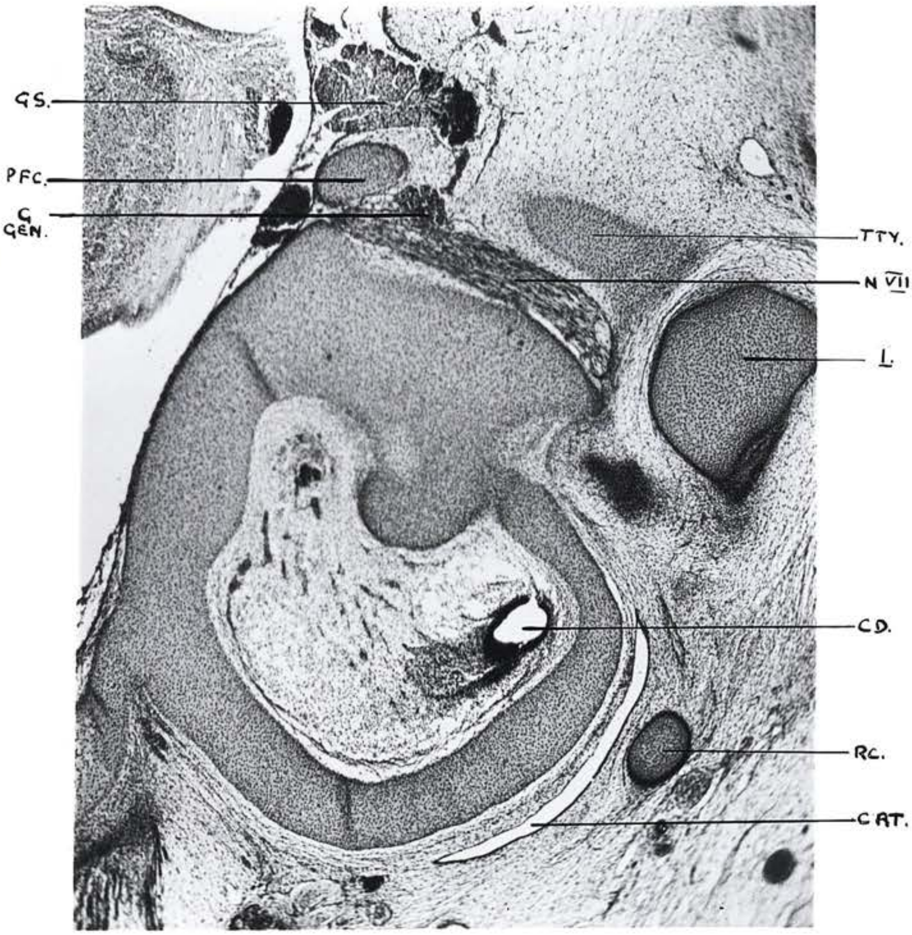

PLATE LXXXVII
G28 - 22 mm H.H.
TRANSVERSE SECTION
OF THE AUDITORY CAPSULE.
STAGE XI.

Plate LXXXVIII

Stage XI

G 28 - 22 mm. H.H.

Transverse Section of the Auditory Capsule

BP - Basal plate.

FAI - Foramen acusticum inferior.

FAS - Foramen acusticum superior.

FOV - Fenestra ovalis.

FR - Foramen rotundum.

FSI - Fossa incudis.

I - Incus.

JV - Jugular vein.

PCP - Paracondylar process.

PPL - Parietal plate.

S - Stapes .

SAC - Saccule.

SH - Stylohyal cartilage.

U - Utricle.

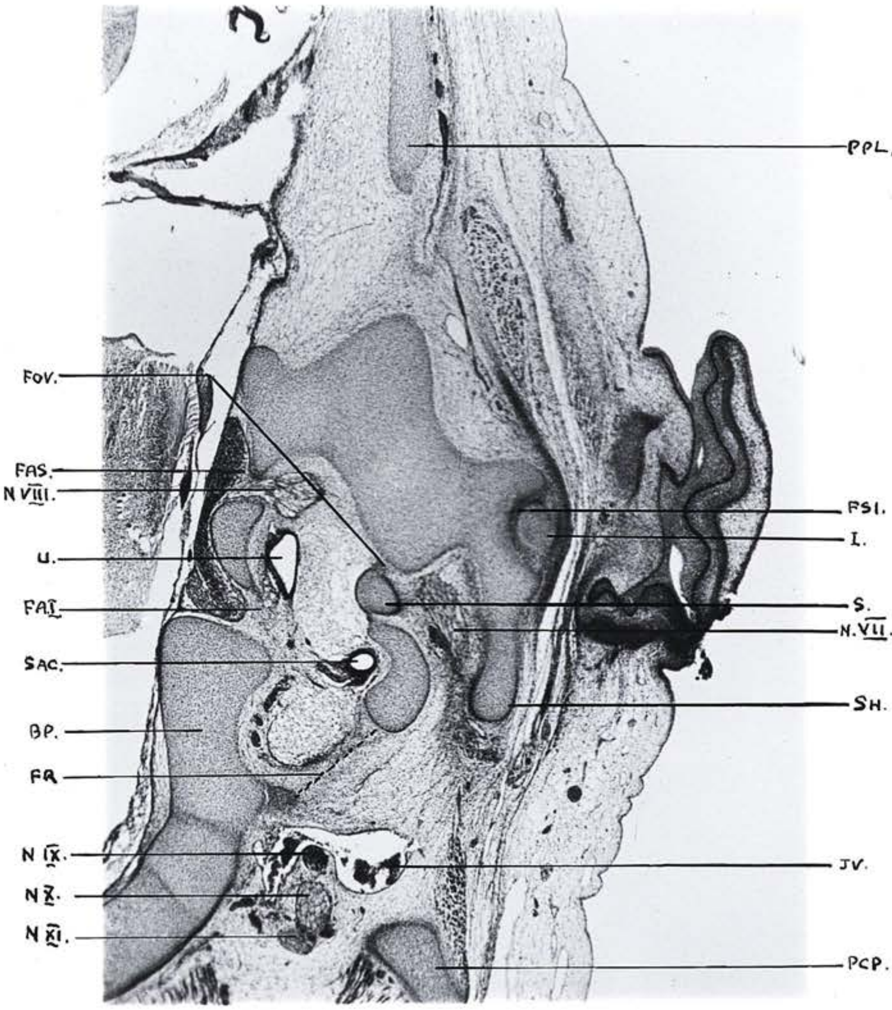

PLATE LXXXVIII
G 28-22 mm. H.H.
TRANSVERSE SECTION
OF THE AUDITORY CAPSULE.
STAGE XI.

Plate LXXXIX

Stage XI

G 28 - 22 mm. H.H.

Transverse Section of the Auditory Capsule

ASC - Anterior semicircular canal.

AMASC - Ampulla anterior semicircular canal.

AMLSC - Ampulla lateral semicircular canal.

CAA - Crista ampullaris anterior.

CAL - Crista ampullaris lateral.

FSAE - Fossa subarcuata externa.

FSAI - Fossa subarcuata interna.

LSC - Lateral semicircular canal.

PSC - Posterior semicircular canal.

PR ASC - Prominence anterior semicircular canal.

U - Utricle.

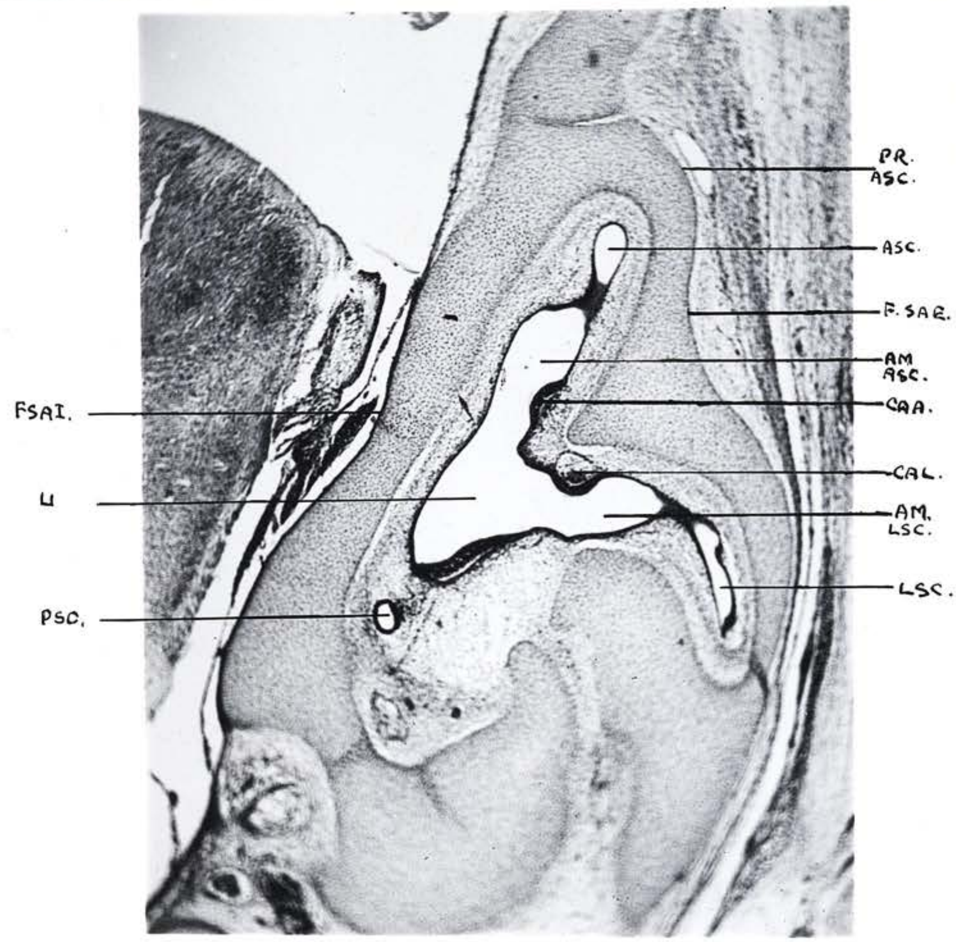

PLATE LXXXIX
G 28 - 22 mm. H.H.
TRANSVERSE SECTION
OF THE AUDITORY CAPSULE.
STAGE XI.

Plate XC

Stage XI

G 28 - 22 mm. H.H.

Transverse Section of the Auditory Capsule

AMPSC - Ampulla posterior semicircular canal.

CAP - Crista ampullaris posterior.

ED - Endolymphatic duct.

JV - Jugular vein.

RJ - Recessus jugulare.

U - Utricle.

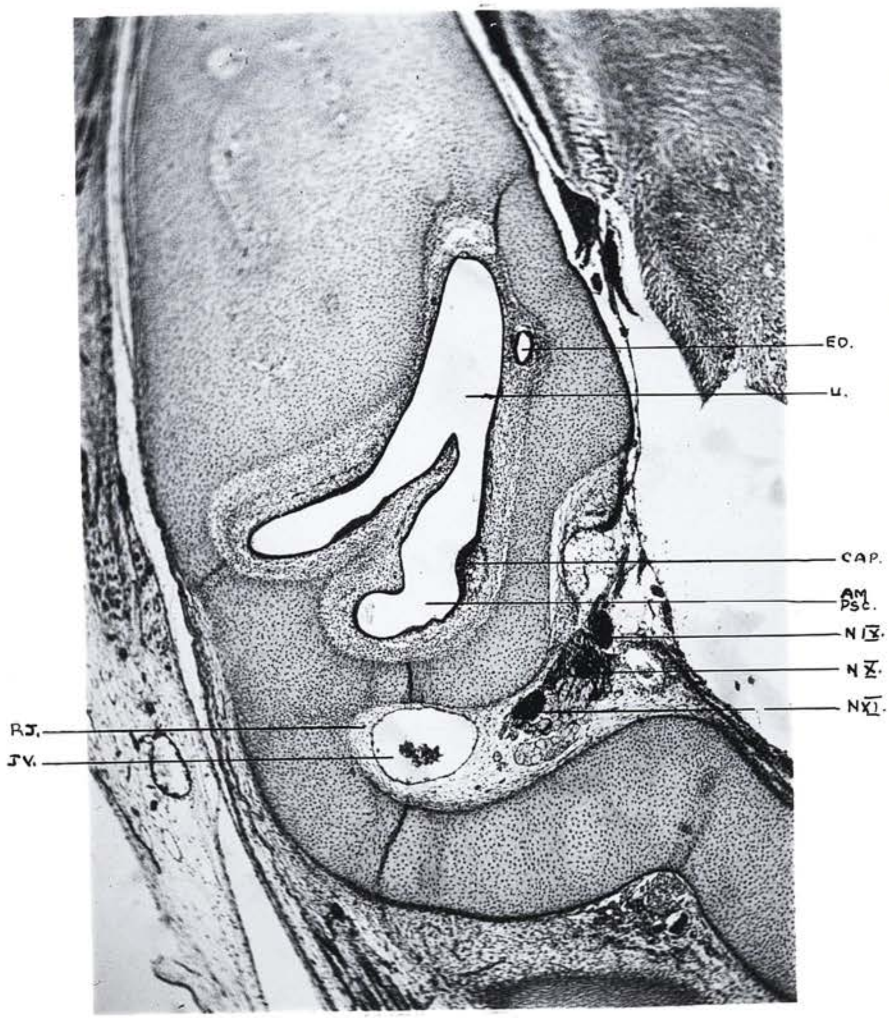

PLATE XC.
G28 – 22 mm. H.H.
TRANSVERSE SECTION
OF THE AUDITORY CAPSULE
STAGE XI.

Plate XCI

Stage XI

G 28 - 22 mm. H.H.

Transverse Section of the Auditory Capsule

ASC - Anterior semicircular canal.

ED - Endolymphatic duct.

PSC - Posterior semicircular canal.

U - Utricle.

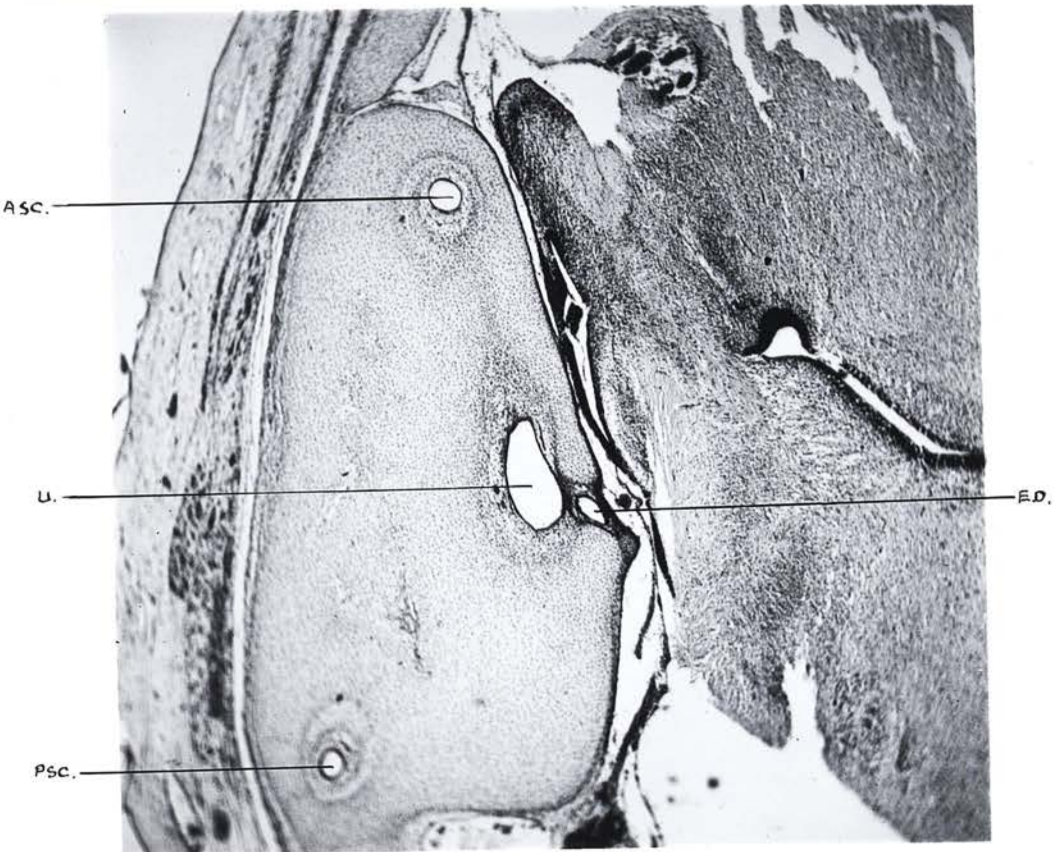

PLATE XCI
G28-22 mm. H.H.
TRANSVERSE SECTION
OF THE AUDITORY CAPSULE.
STAGE XI.

Plate XCII

Stage II

G 33 - 14 mm. H.H.

DEN - Dentary.

FIO - Infraorbital foramen.

FRO - Frontal bone.

JUG - Jugal (Malar).

MAX - Maxillary bone.

MXZ - Zygomatic process of maxilla.

SQ - Squamosal.

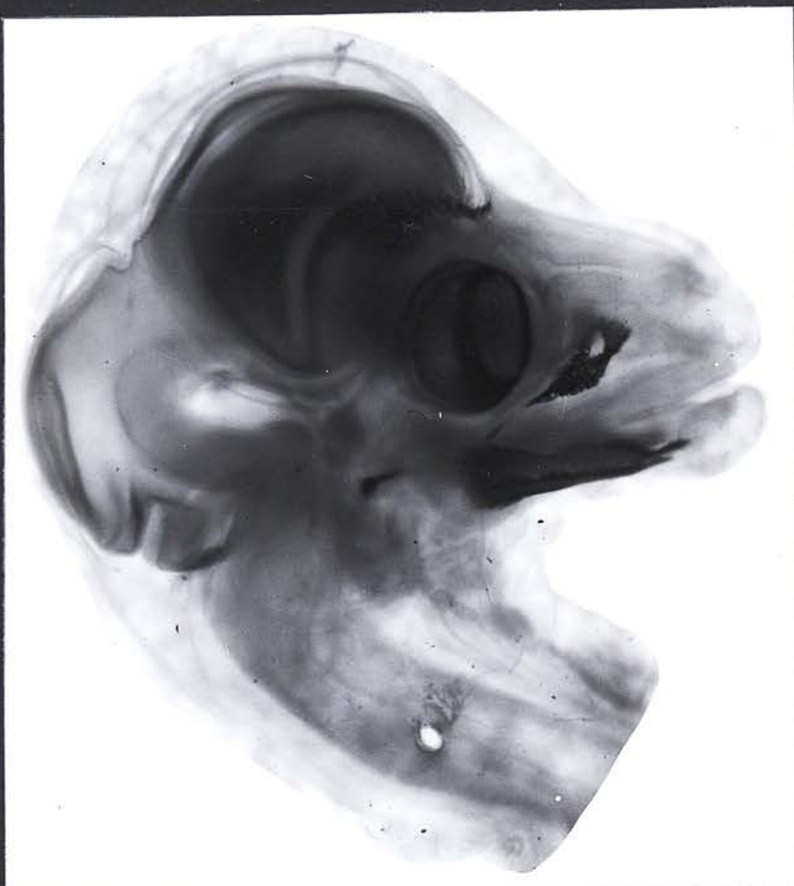

PLATE XCII. STAGE II.
G33 14 mm. H.H.

PLATE XCII. STAGE II.
G 33 14mm. H.H.

Plate XCIII

Stage III

G 4 - 16 mm. H.H.

CP - Coronoid process.

DEN - Dentary.

FRO - Frontal bone.

HB - Hyoid bone.

JUG - Jugal or Malar.

LAC - Lachrymal bone.

MAX - Maxillary bone.

MF - Mental foramen.

NPMX - Nasal process of premaxillary bone.

OF - Orbital plate of frontal bone.

PAR - Parietal bone.

SQ - Squamosal.

PLATE XCIII. STAGE III.
G4 16 mm. H.H.

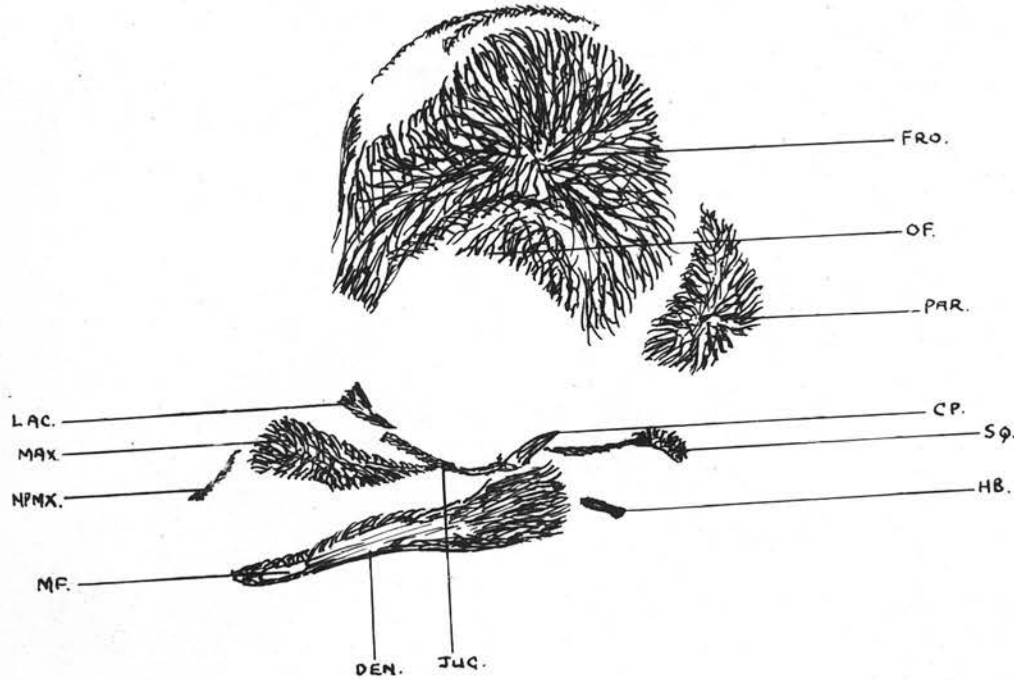

PLATE XCIII. STAGE III.
G4. 16 mm. H.H.

Plate XCIV

Stage IV

G 34 - 17 mm. H.H.

CP - Coronoid process.

DEN - Dentary.

FRO - Frontal bone.

HB - Hyoid bone.

JUG - Jugal or Malar.

MAX - Maxillary bone.

NPMX - Nasal process of premaxillary bone.

OC - Occipital condyle.

OF - Orbital plate of frontal bone.

PAR - Parietal bone.

SQ - Squamosal.

PLATE XCIV. STAGE IV.
G34 17 mm. H.H.

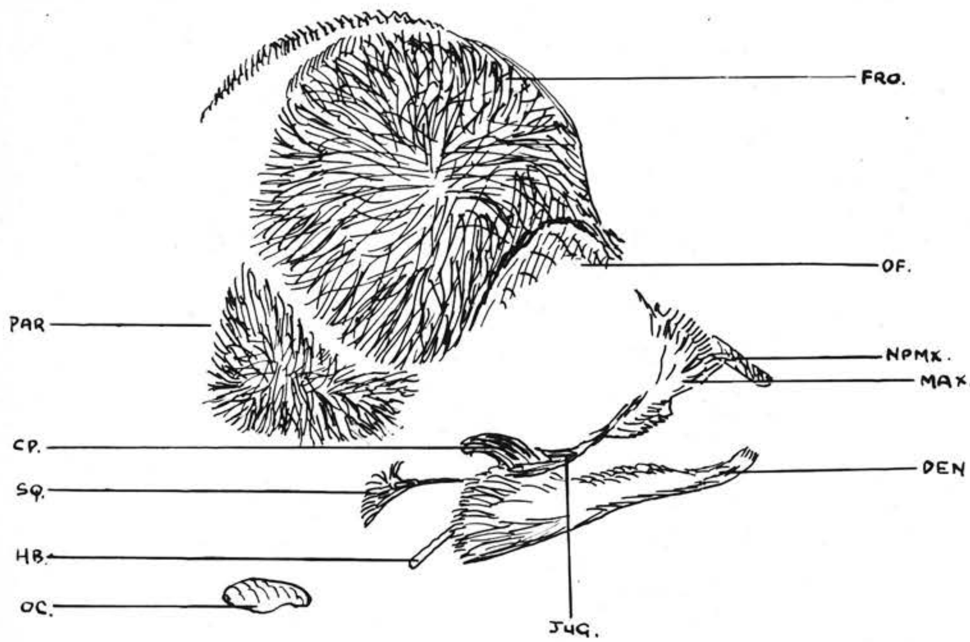

PLATE XCIV STAGE IV.
G34.17 mm. H.H.

Plate XCV

Stage V

G 30 - 19 mm. H.H.

CP - Coronoid process.

DEN - Dentary.

FRO - Frontal bone.

HB - Hyoid bone.

JUG - Jugal or malar.

LAC - Lachrymal bone.

M - Malleus.

MF - Mental foramen.

NAS - Nasal bone.

NPMX - Nasal process of premaxillary bone.

OC - Occipital condyle.

OF - Orbital plate of frontal bone.

PAR - Parietal bone.

SQ - Squamosal.

TY - Tympanic bone.

PLATE XCV STAGE V.
G30 19 mm. H.H.

PLATE XCV. STAGE V.
G30 19 mm. H.H.

Plate XCVI

Stage VI

G 3 - 22 mm. H.H.

CP - Coronoid process.

DEN - Dentary.

FRO - Frontal bone.

HB - Hyoid bone.

JUG - Jugal or malar.

LAC - Lachrymal bone.

MAX - Maxillary bone.

NAS - Nasal bone.

NPMX - Nasal process of premaxillary bone.

OC - Occipital condyle.

OF - Orbital plate of frontal bone.

PAR - Parietal bone.

SQ - Squamosal.

TY - Tympanic bone.

PLATE XCVI. STAGE VI.
G3 22 mm. H.H.

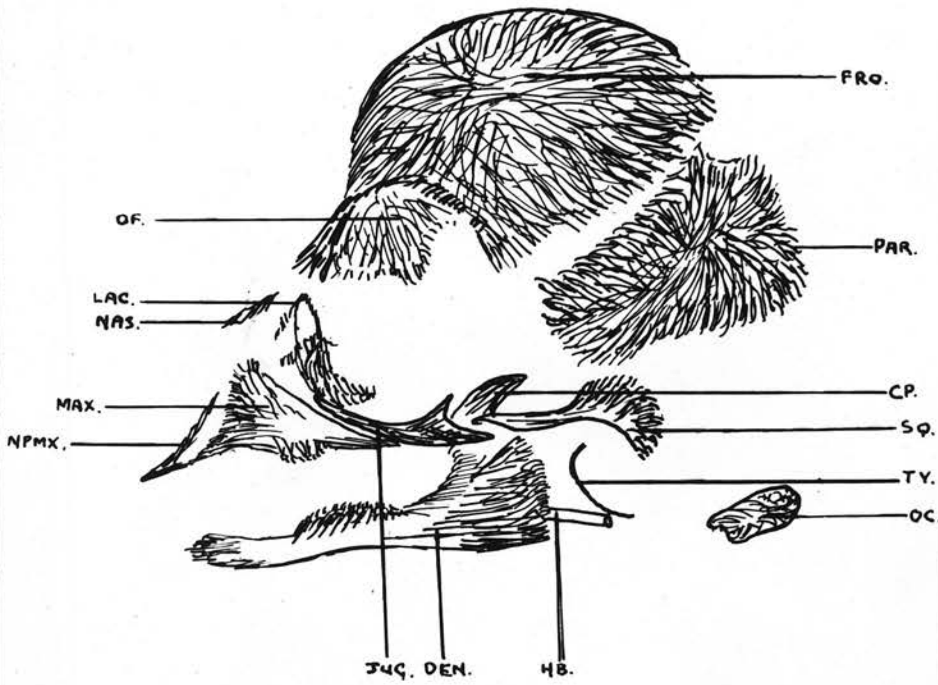

PLATE XCVI. STAGE VI.
G3. 22 mm H.H.

Plate XCVII

Stage VII

G 35 - 25 mm. H.H.

ALI - Alisphenoid bone.

BO - Basioccipital bone.

DEN - Dentary.

FRO - Frontal bone.

HB - Hyoid bone.

LAC - Lachrymal bone.

M - Malleus.

MAX - Maxillary bone.

NAS - Nasal bone.

NPMX - Nasal process of premaxillary bone.

OC - Occipital condyle.

ORS - Orbitosphenoid.

PAR - Parietal bone.

SOB - Supraoccipital bone.

TY - Tympanic bone.

PLATE XCVII. STAGE VII.
G35 25 mm. H.H.

PLATE XCVII STAGE VII
G 35 - 25 m.m H.H

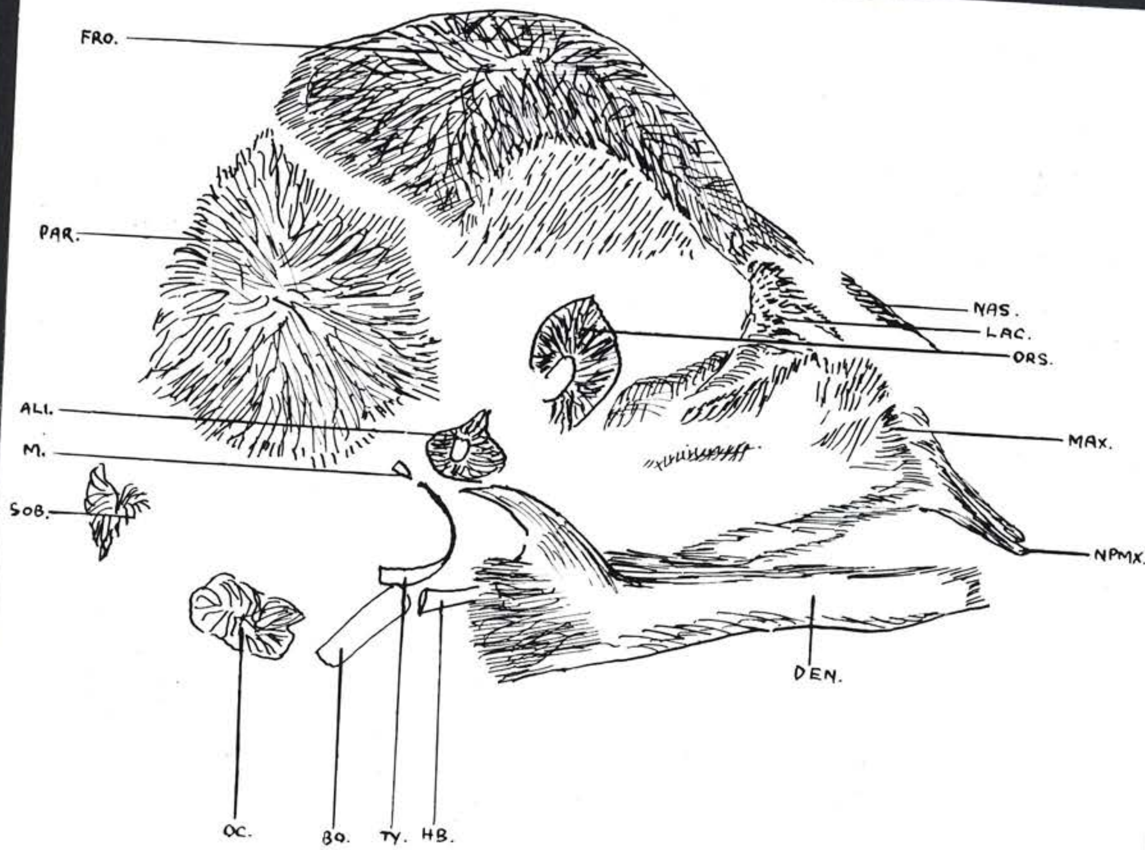

PLATE XCVII. STAGE VII.
G35. 25 mm. H.H.

Plate XCVIII

Stage VII

G 35 - 25 mm. H.H.

BS - Basisphenoid.

DEN - Dentary.

HB - Hyoid bone.

JUG - Jugal or Malar.

MAX - Maxillary bone.

MXP - Palatine process of maxilla.

PAB - Palatine bone.

PMX - Premaxillary bone.

PTG - Pterygoid bone.

PVP - Palatine process of premaxilla.

PLATE XCVIII. STAGE VII.
G35 25mm. H.H.

PLATE XCVIII. STAGE VII.
G35 25 mm. H.H.

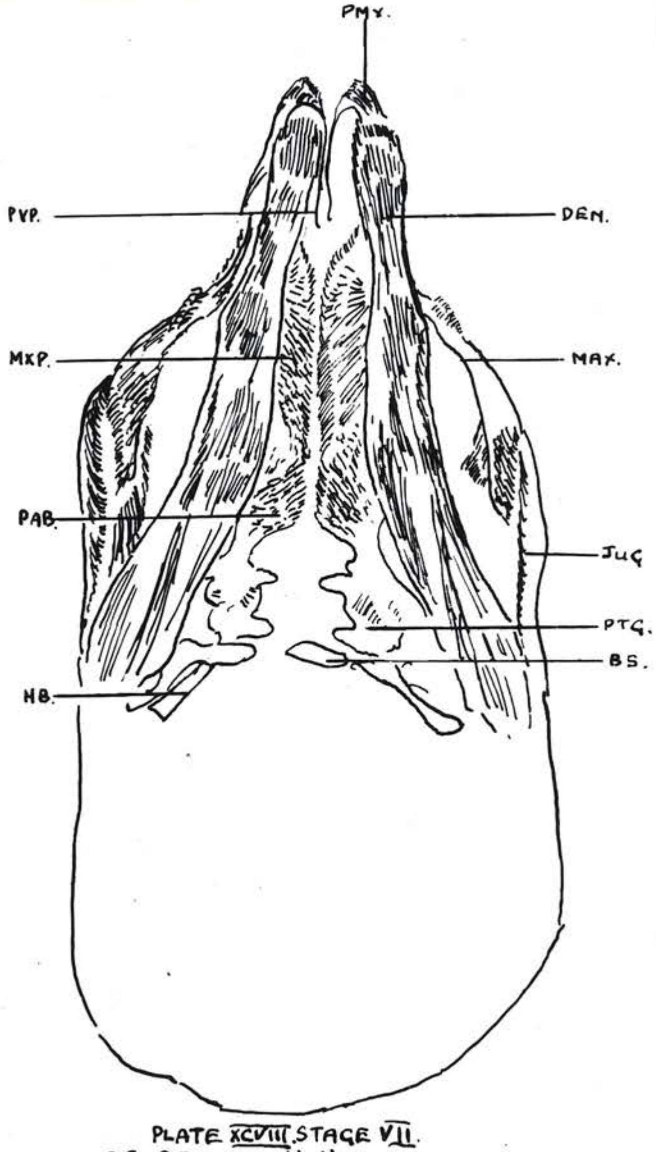

PLATE XCVIII. STAGE VII.
G35. 25 mm. H.H.

Plate XCIX

Stage VIII

G 29 - 31 mm. H.H.

BPMX - Body of premaxillary bone.

CP - Coronoid process.

DEN - Dentary.

FRO - Frontal bone.

HB - Hyoid bone.

JUG - Jugal (or Malar).

LAC - Lachrymal bone.

MAX - Maxillary bone.

NAS - Nasal bone.

NPMX - Nasal process of premaxillary bone.

OC - Occipital condyle.

OF - Orbital plate of frontal bone.

ORS - Orbitosphenoid.

PAR - Parietal bone.

SOB - Supraoccipital bone.

SQ - Squamosal.

TY - Tympanic bone.

PLATE XCIX. STAGE VIII.
G29 31mm. H.H.

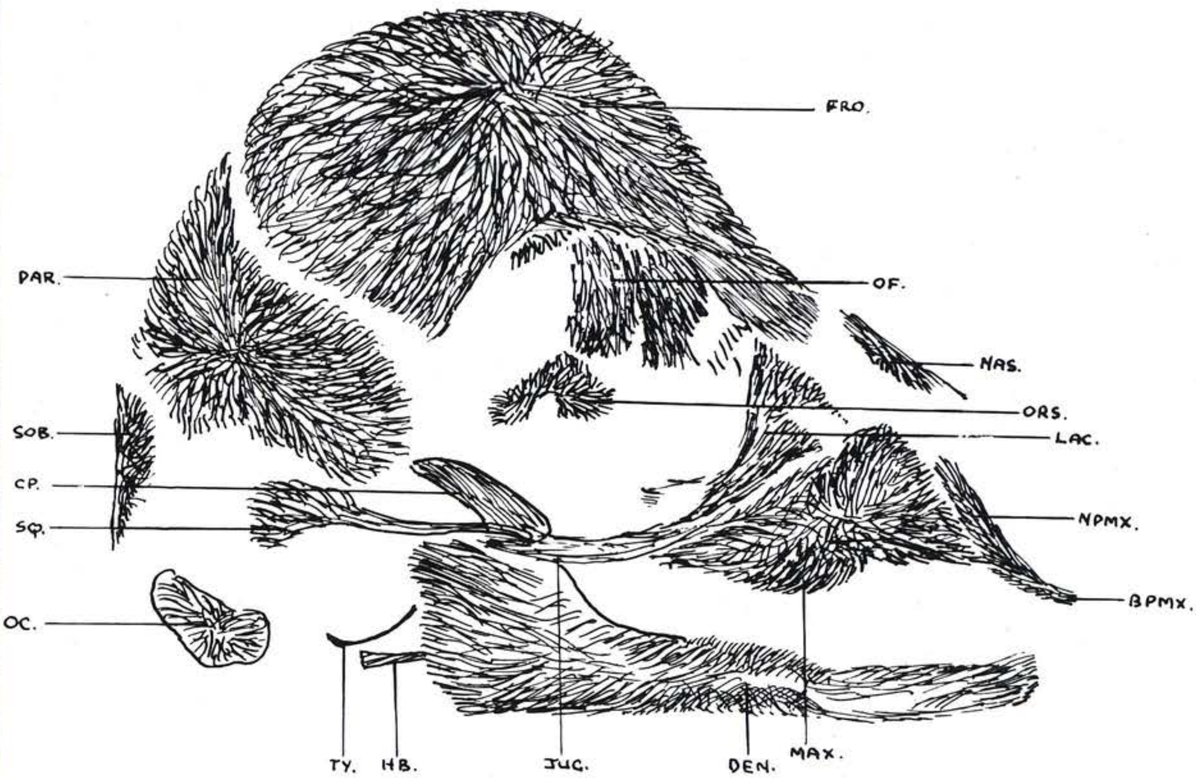

PLATE XCIX. STAGE VIII.
G29. 31 mm H · H.